WIRELESS ENGINEER

THE JOURNAL OF RADIO RESEARCH & PROGRESS

AUGUST 1953

VOL. 30 No. 8 THREE SHILLINGS AND SIXPENCE

The PERFECT TEST TEAM

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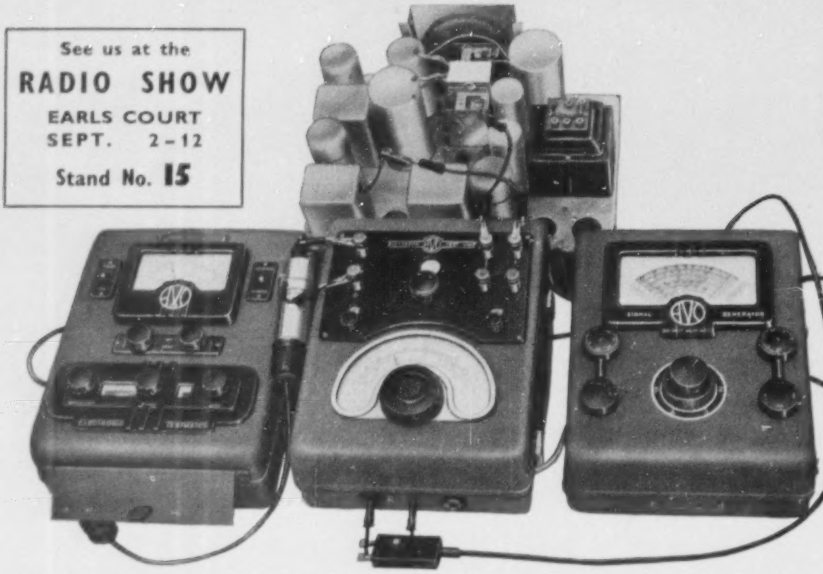

The illustration depicts a set of modern "AVO" testgear being used to measure the "Q" of the secondary winding of the second I.F. transformer on a chassis of unknown characteristics—just one of many tests which can be performed by this combination of instruments.

A signal of predetermined frequency from the "AVO" Wide Range Signal Generator is being fed into the Electronic Test Unit, where it is amplified and fed to the secondary winding of the transformer. The Electronic Testmeter is connected across the tuned circuit under test and from the readings obtained and the controls of the Electronic Test Unit, the "Q" of the circuit can be determined.

The three instruments, shown as a team, cover a very wide field in measurement and form between them a complete set of laboratory testgear, ruggedly constructed to withstand hard usage.

ELECTRONIC TESTMETER

A 56-range instrument combining the sensitivity of a delicate galvanometer with the robustness and ease of handling of an ordinary multi-range meter. Consists basically of a highly stable D.C. Valve Millivoltmeter, free from mains variations and presenting negligible load on circuit under test. Switched to measure:—

D.C. Volts: 5mV to 10,000V.
D.C. Current: 0·5μA to 1 Amp.
A.C. Volts: ·1V to 2,500V R.M.S. up to 2 Mc/s.
·1V to 250V R.M.S. up to 200 Mc/s.
A.C. Power Output: 5mW to 5 Watts
Decibels: −10db to + 20db. Zero level 50 mW.
Capacitance: ·0001μF to 50μF.
Resistance: ·2ohm to 10 Megohms

Operates on 100-130v. and 200-260v. 50-60 c/s A.C. Mains.

ELECTRONIC TEST UNIT

For measuring small values of A.C. voltage, inductance, capacity, and "Q" at radio frequencies. Although designed primarily for use with "AVO" instruments, it can be used with any suitable Signal Generator/Valve Voltmeter combination.

As a **Wide Range Amplifier**, it is capable of an amplification factor of 40 ± 2−3db between 30c/s and 20 Mc/s.

As a **Capacity Meter**, it covers measurements at radio frequency from ·5pF to 900pF in two distinctly calibrated ranges.

As an **Inductance Meter**, it gives direct measurements from ·5μH to 50mH in six ranges.

As a **"Q" Meter**, it indicates R.F. coil and condenser losses at frequencies up to 20 Mc/s.

Operates on 100-130v. and 200-260v. 50-60 c/s A.C. mains.

WIDE RANGE SIGNAL GENERATOR

An instrument of wide range and accuracy for use with modern radio and television circuits.

Turret coil switching provides six frequency ranges covering 50 Kc/s to 80 Mc/s.

Range 1. 50 Kc/s—150 Kc/s
" 2. 150 Kc/s—500 Kc/s
" 3. 500 Kc/s—1·5 Mc/s
" 4. 1·5 Mc/s—5·5 Mc/s
" 5. 5·5 Mc/s—20 Mc/s
" 6. 20 Mc/s—80 Mc/s

Accuracy to within 1% of scale marking. Gives sensibly constant signal of good wave-form, modulated or unmodulated, over entire range. Minimum signal less than 1μV at 20 Mc/s and less than 3μV between 20 and 80 Mc/s. Gives calibrated output from 1μV to 50mV.

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Battery-operated model also available.

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(A.C. OUTPUT)

- **EXTREMELY PRECISE CONTROL (CONSTANCY 0·15%)**
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- **EXCELLENT REGULATION FROM ZERO TO 100% LOAD**
- **VERY COMPACT ● LIGHTWEIGHT ● FOOLPROOF**

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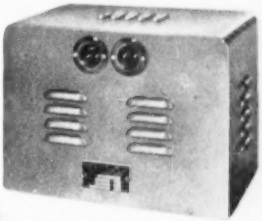
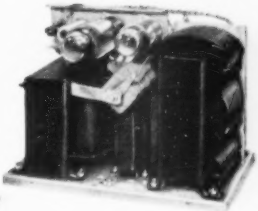


Rear View BAVR-200

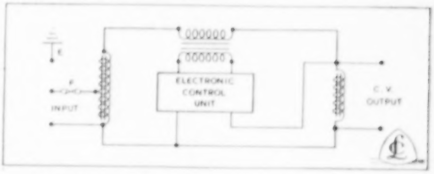
The control unit is a magnetic amplifier, the inductance of which varies with the DC passed through control coils. Stabilization is achieved by monitoring the output side and regulating automatically the D.C. component so as to adjust the AC output voltage and keep it constant within precise limits, the stability being 0·15%. The functional circuit is as shewn. The Electronic Control Unit employs three tubes—one each EL37, 90C1 and A2087, and a selenium rectifier: it is foolproof.



Inside View BAVR-200

Usual Input Voltage "Swing" is 230V—12% to + 6%, and usual output voltage 230V, tolerance 0·15%, and means are provided so that the instruments may be changed by the customer, to suit them to other input voltages from 200-250V, nominal.

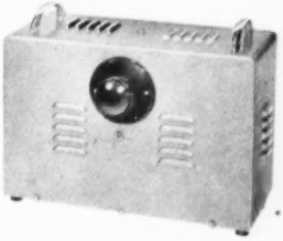
We are also now in a position to accept orders for three larger models, type BMVR: these work on a different and still newer principle, which includes all the good features of "BAVR" plus the ability to cater for large or very large loads, plus undistorted output (sinusoidal, and free from troublesome harmonics).



Functional Circuit BAVR

TYPE	MAXIMUM LOAD	NET PRICE
BAVR-200	200 VA	£50 0 0
BAVR-500	500 VA	£57 10 0
BAVR-1,000	1 kVA	£70 0 0
BMVR-1,725*	Ca. 2 kVA	£75 0 0
BMVR-7,000*	Ca. 7 kVA	Prices on application
BMVR-25,000*	Ca. 25 kVA	

* Full details now in active preparation, and will gladly be sent on written request. These three Instruments have sinusoidal output waveform (no percentage of harmonics).



Model BMVR-1725

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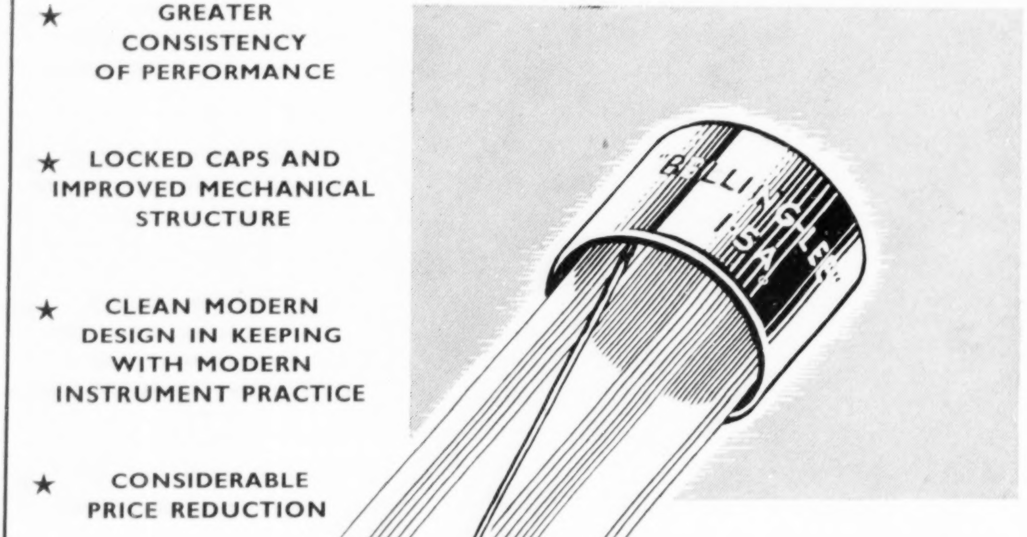
- ★ CONSIDERABLE PRICE REDUCTION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1.5A.
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1.5A.

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The fuses are made in ratings from 60 mA to 25 amps, but we do not guarantee that ratings above 7½ amps will clear the high prospective currents specified for the lower ratings.

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100 Kc/s – 100 Mc/s ON

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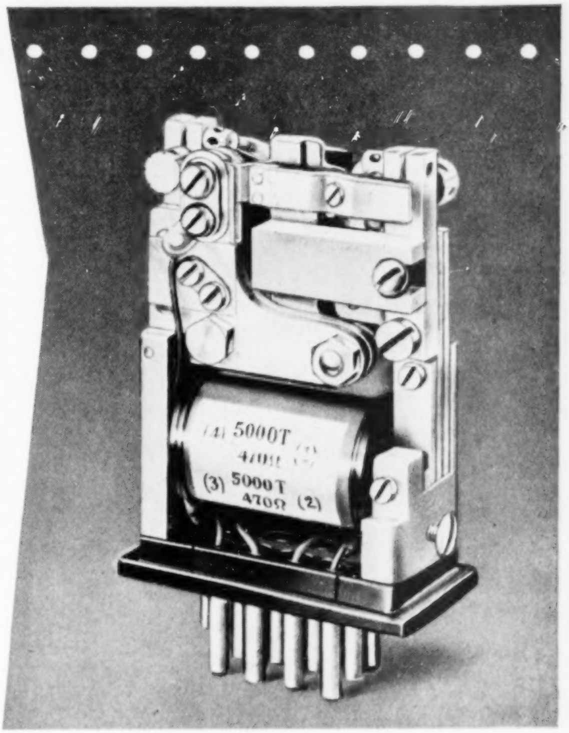

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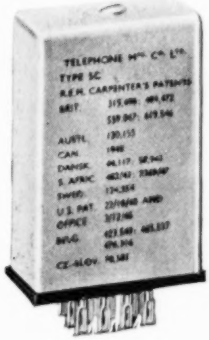

Type 5 Relay with cover.

Plug or solder tag base optional.

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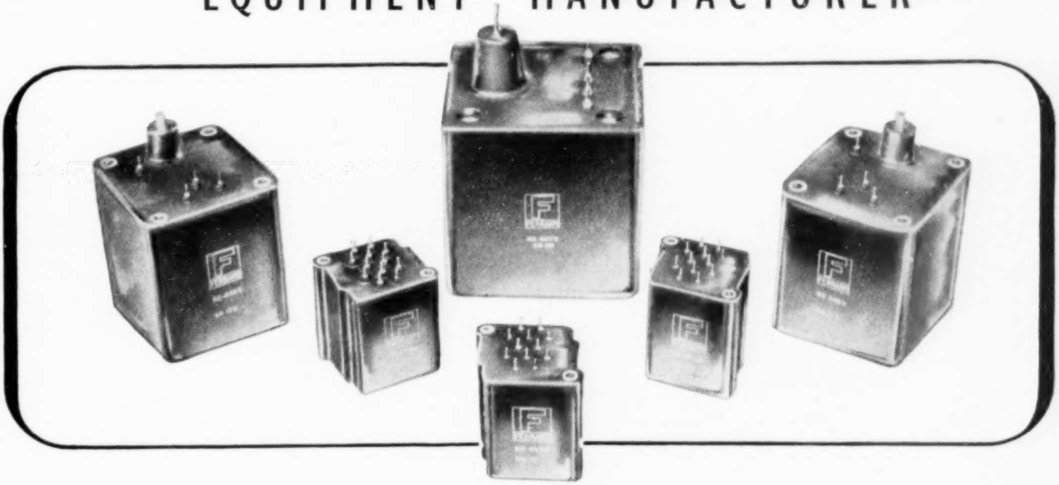

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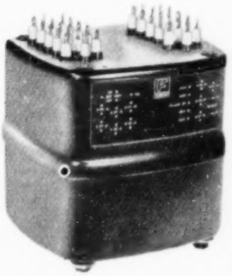

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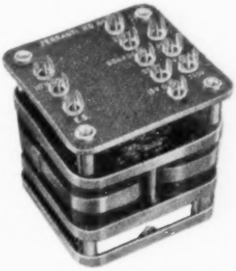

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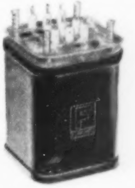

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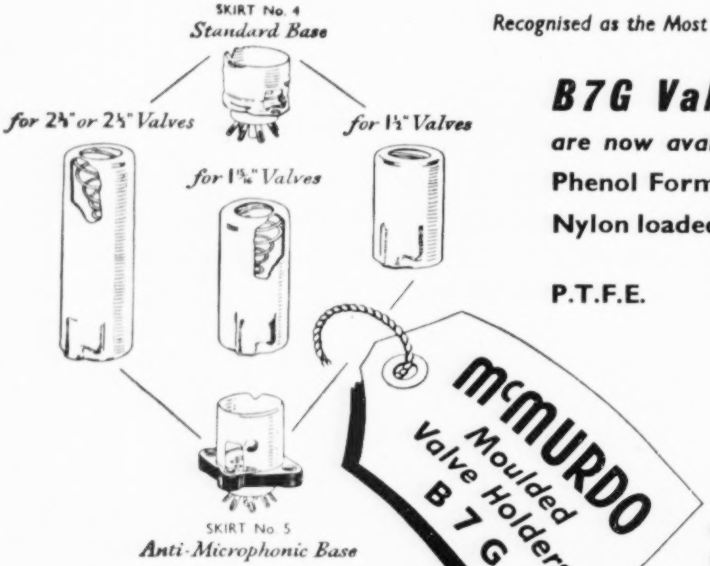
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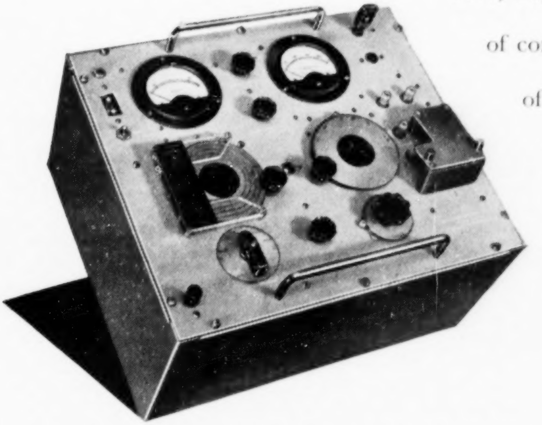

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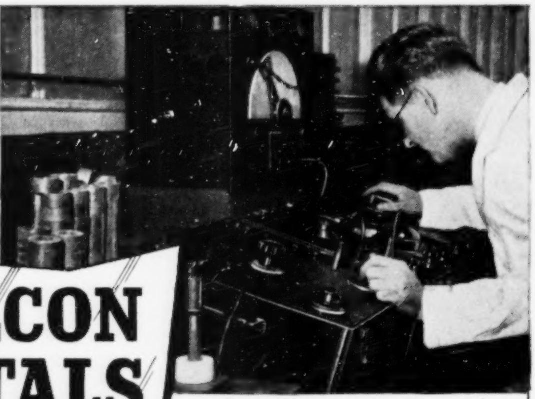

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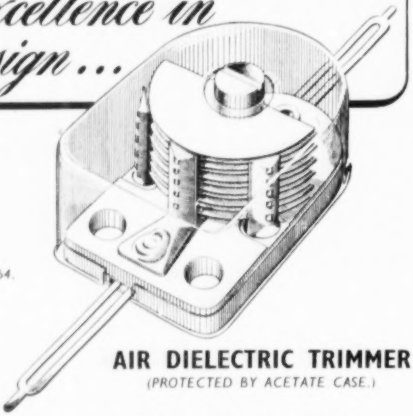

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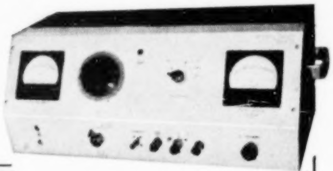

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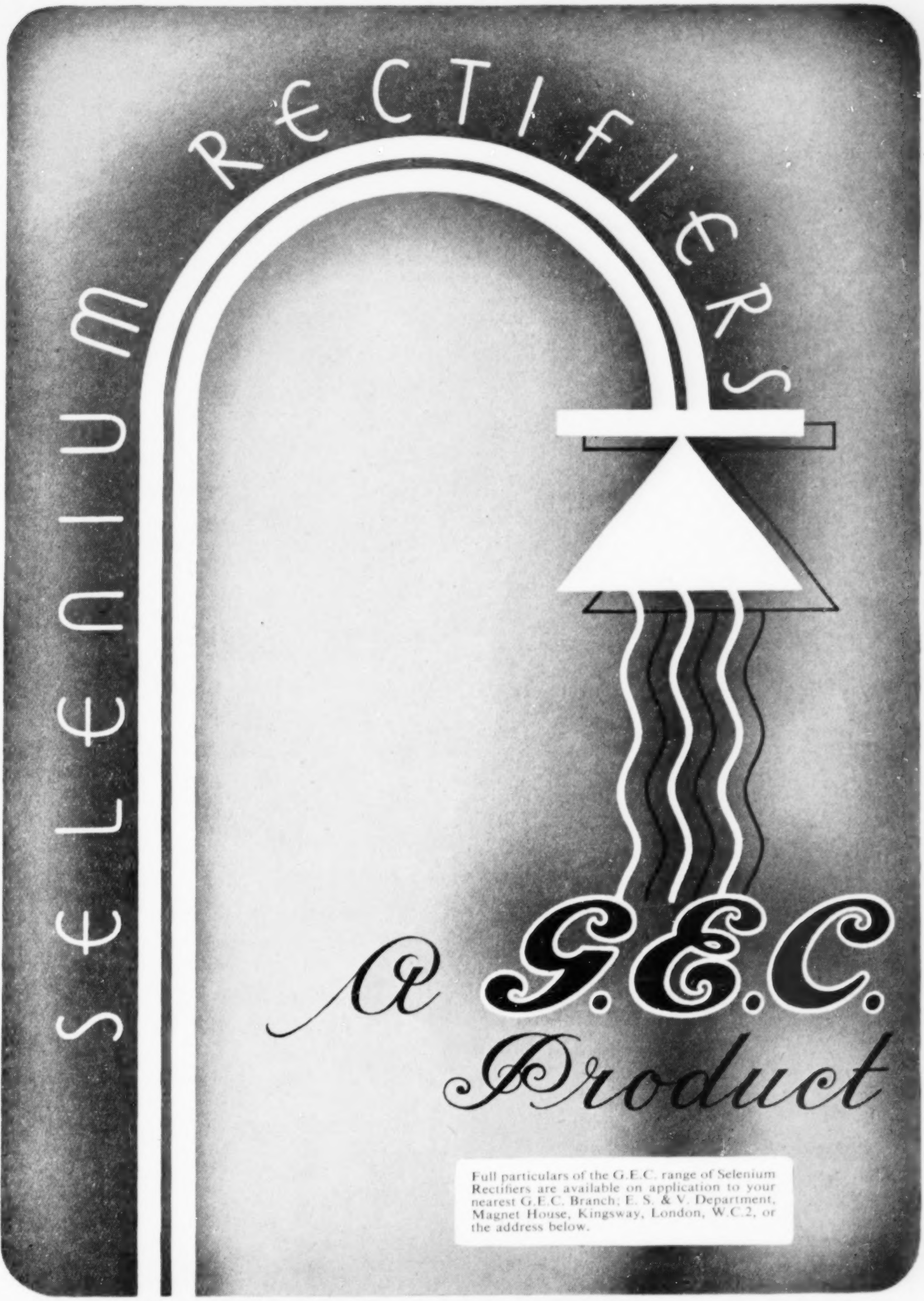

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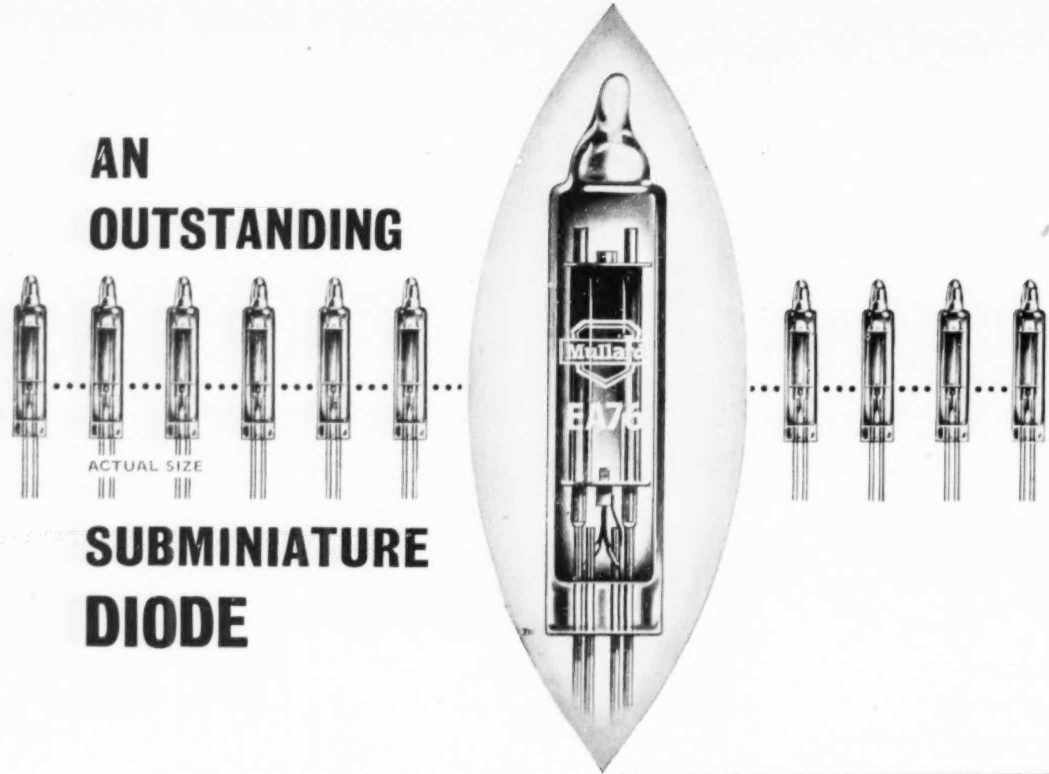

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Vol. 30 AUGUST 1953 No. 8

Germanium

IN 1869, when Mendeleev developed his periodic law, there were numerous gaps in his tabulated lists of elements which were subsequently filled by the discovery of new elements. One group, which should have contained five elements, contained only four known elements, viz. carbon, silicon—tin, lead, of approximate atomic weights, 12, 28—117, 206, and Mendeleev called the missing element eka-silicon and predicted its atomic weight (72) and some of its properties. In 1886 Winkler discovered the missing element and gave it the name germanium. It is seen that it forms a link between carbon and silicon on the one hand and tin and lead on the other, and can be regarded as being both metallic and non-metallic; its oxide unites with acids as do those of copper and lead, while it combines with alkaline hydroxides to form germanates, as silicon does to form silicates.

We now know that the nucleus of the germanium atom contains 32 protons and 40 neutrons, thus making up the atomic weight of 72; the nucleus is surrounded by 32 electrons in four layers containing respectively 2, 8, 18 and 4 electrons. The four electrons of the outer layer constitute the links with the neighbouring atoms, the attractive force being due to the spin of the electrons in the appropriate direction. Every atom, having four of these links, occupies the centre of a regular tetrahedron with its four neighbours at the corners as shown in Fig. 1. The crystalline structure is seen to be a centre-faced cube; carbon also has four peripheral electrons and a diamond has a similar crystalline structure. At absolute zero temperature there would be no free electrons; "the peripheral electrons would all be mobilized to form an interatomic cement; the germanium would then be a perfect insulator."* It is, of course, only the atoms in Fig. 1 that have any concrete existence; the connecting rods represent the forces acting between the atoms, and their length is greatly exaggerated since the atoms are relatively very much larger than shown in Fig. 1 and are practically in contact.

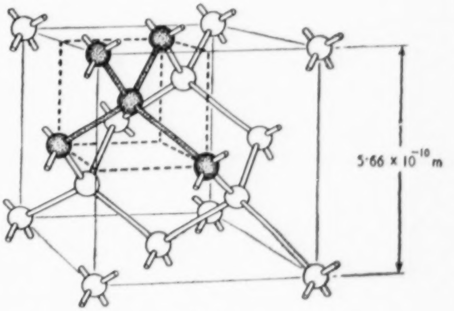

Fig. 1.

As the temperature is raised the mean energy of thermal agitation of the electrons increases, and a certain number of them attain such momentary energy that they break away from the atom, to be captured later by another atom which has lost an electron. As the temperature is increased the number of free electrons at any moment increases and therefore the conductivity increases with the temperature; this is characteristic of semi-conductors. In an insulator the energy required to liberate an electron is so great that the temperature necessary to produce it would destroy the material. If the energy required has a moderate value, the conductivity may increase rapidly with the temperature, as in thermistors. In a conductor the number of free electrons is approximately equal to the number of atoms and almost independent of the temperature; in this case increased thermal agitation of the atoms hinders the passage of the free electrons and thus causes increased resistance. A comparison of the conductivities of copper and germanium shows that in the latter there is only one free electron for about a million atoms, even when impurities are present.

---

* Dr. J. Laplume, *Bull. de la Société Française des Electriciens*, March 1953, p. 125.

For every free electron there is a deficiency in the outer layer of an atom; this is referred to as a hole and is equivalent to a positive charge. There will be continual change, since an atom may have a hole at one moment and by capturing an electron be neutral the next moment. When an electric field is applied there is a drift of free electrons in one direction and a drift of holes in the opposite direction.

The conductivity can be greatly increased by the presence of impurities. Atoms of phosphorus, nitrogen, arsenic and antimony have five electrons in the peripheral layer, and such an atom, when linked up with the neighbouring germanium atoms, has one electron without a link, which therefore, although attracted to its own nucleus, is easily moved away. On the other hand, an atom of boron or aluminium has only three peripheral electrons but may fit itself into the surrounding structure by appropriating an electron from a neighbouring atom and thus creating a hole which will be acted on by the applied electric field. Silicon always contains some boron and its conductivity is therefore of this latter type, whereas germanium is more likely to contain arsenic or antimony and therefore have conductivity of the former type. Where the conductivity is mainly due to the movement of electrons it is said to be of the *n* type; where it is mainly due to the movement of holes it is said to be of the *p* type.

At a junction between the two different types of germanium the excess of electrons in the *n* type will diffuse across the junction and the excess of holes in the *p* type will diffuse in the opposite direction, thus setting up a difference of potential and an electric field which increases until a state of equilibrium is reached and no further diffusion takes place. If an external p.d. is now applied in the same direction as that across the junction it will only seal the barrier more securely and remove the last traces of diffusion, whereas if it is applied in the opposite direction it will promote increased diffusion and enable electrons and holes with little kinetic energy to cross the barrier. Since the great majority of them are in this category, the current increases rapidly with the applied voltage; in an actual case—the 4JA2A4 germanium rectifier made by the General Electric Co. (of America)—an applied voltage of 0·5 V produced a current of 0·5 A, while in the reverse direction 250 V was required to pass a current of 0·1 mA. In the pass direction the current increases exponentially with the voltage up to values at which a limit is fixed by the heating. The maximum permissible reverse voltage depends on the purity of the germanium but is about 1,000 V; on reaching a certain voltage the barrier breaks down and the current jumps suddenly to a high value. The purity aimed at is beyond chemical analysis, and can only be tested by electrical methods; to obtain a reverse voltage limit of 1,000 V there must be less than one atom of impurity to 200 million atoms of germanium.

One of the most striking suggestions recently made is the use of germanium rectifiers on electric locomotives to convert the a.c. supply to d.c. for the driving motors. It is claimed that with a sufficient factor of safety a square centimetre of germanium could supply a power of 40 kW and that therefore a total cross-section of 100 cm^2 would be suitable for a 4,000-horse-power locomotive. The cooling would need special attention, as with the claimed efficiency of over 95% the heat produced in the germanium would be about 150 kW, and the rectifying properties deteriorate rapidly if the temperature exceeds about 70°C. Because of the unsuitability of germanium at high temperatures, research is in progress in the laboratories of the Compagnie Française Thomson-Houston (loc. cit. p. 134) as to the possibility of replacing it by silicon. At present, except above 70°C, germanium is superior to all other materials, although even above 35°C it is inferior to selenium and copper oxide so far as reverse current is concerned. These developments will certainly come as a surprise to anyone who has only associated germanium with rectifiers of the miniature type.

G. W. O. H.

RADIO DIRECTION FINDING

Influence of Buried Conductors on Bearings

By F. Horner, M.Sc., A.M.I.E.E.

(Communication from the D.S.I.R., Radio Research Station, Slough)

SUMMARY.—The currents induced, at low frequencies, in a buried cable in good contact with the ground may greatly exceed those in a similar cable insulated from the ground. These currents may lead to large errors in a loop direction finder, even when the length of the cable is a small fraction of the wavelength. The errors are likely to be small if the direction finder is near one end of the cable. Formulae are derived for the currents induced in a buried conductor and these lead to calculated errors in reasonable agreement with measured errors, at a frequency of 10 kc/s.

The results show that the effect of burying a cable in soil of good conductivity is to increase errors at low frequencies and to reduce errors at high frequencies. The transition frequency depends on the length of the cable and is, for example, about 300 kc/s for a cable 200 metres long.

Adcock direction finders are less liable to errors due to cables, but there is some risk of errors if a cable is laid in close proximity to an aerial feeder.

1. Introduction

IN the operation of cathode-ray direction finders for the location of sources of atmospherics, errors have been observed which have been attributed to imperfections of the site. The power and telephone cables leading to, and terminating at, the installations were considered to be a possible source of error and an investigation of their influence was undertaken. The direction finders operated at a frequency of 10 kc/s and the aerials were crossed-loops spaced 2 metres between centres.

Cables have long been recognized as a cause of direction-finding errors in a wide range of frequencies, particularly with aerial systems incorporating vertical loops.[1] W. Ross[2] has shown that at high frequencies cables can cause serious errors when laid on the ground, and it is customary to bury them to reduce their influence. R. L. Smith-Rose[3] observed errors up to 7 degrees on a rotating-loop beacon at a frequency of 570 kc/s and attributed these to buried electric power cables. The errors were smaller at a frequency of 290 kc/s. In a qualitative explanation, the errors were shown to be caused by the currents in the cables induced by the horizontal component of electric field in the tilted wavefront of a vertically-polarized wave. At a lower frequency (77 kc/s) errors of 14 degrees have been caused by a strip of expanded steel 300 ft long and 6 ft wide, buried to a depth of 8 ft.[4]

There is little evidence relating to the influence of cables at frequencies below 100 kc/s. As the frequency is reduced, the forward tilt of an incident wave becomes less and this tends to reduce the current induced in a cable. However, the current is also affected by the length of the cable relative to the wavelength and by the impedance of the cable, which is frequency-dependent. In this paper these factors are discussed and theoretical estimates of the errors to be expected at a frequency of 10 kc/s are compared with measured values.

2. The Effect of Burying a Cable

For the purpose of this discussion the cable will be treated as a straight, bare conductor in good contact with the ground when buried. The important conductor is the screen of a lead-covered or armoured cable; the inner conductors which are insulated from the ground may be disregarded. The discussion does not apply to a cable surrounded by an effective insulating sheath.

When a conductor is in free space and energized by an electric field it carries a current which is determined by its self-capacitance and other properties. At very low frequencies the capacitive paths have high impedance and the currents flowing are correspondingly small. If now the conductor is placed in good contact with the ground, conductive paths for the currents are provided and these have relatively low impedance. The currents may then be considerably greater than those in an insulated conductor.

The effect of burying a conductor has been demonstrated in experiments using a direction finder at 10 kc/s. The loop aerials were placed over the mid-point of a lead-covered cable 200 metres long lying on the surface of the ground. Bearings on lightning flashes were compared with those obtained on a second direction finder on a nearby clear site. The errors observed are plotted as a function of azimuth in Fig. 1(a). The aerials were then placed over the mid-point of a similar cable, also 200 metres long, buried to a depth of 40 cm. The errors, plotted in Fig. 1(b), were much greater and the form of the mean curve (broken line) bore approximately the correct relation to the orientation of the cable.

MS accepted by the Editor, December 1952.

The solid curve on Fig. 1(b) has been derived by calculation and will be discussed in Section 6.1.

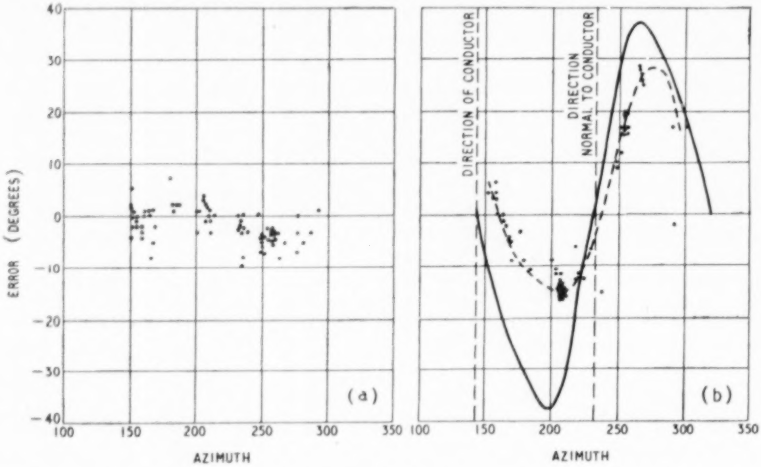

Fig. 1. *Bearing errors due to exposed and buried conductors.* (a) *Errors at mid-point of conductor on the surface of the ground;* (b) *errors at mid-point of conductor* 40 *cm below the surface. Length of conductors* 200 *m.*

3. Current Induced in a Buried Conductor

By regarding a conductor as a transmission line with uniform characteristic impedance Z_0 and propagation constant γ, it may be shown that a uniform electric field E directed along the conductor induces a current

$$i_x = \frac{E}{\gamma Z_0} \cdot \frac{2 \sinh \frac{1}{2}\gamma x \;.\; \sinh \frac{1}{2}\gamma(l - x)}{\cosh \frac{1}{2}\gamma l} \quad .. \quad (1)$$

at a point distance x from either end. l is the total length of the conductor.

At the mid-point ($x = l/2$)

$$i_c = \frac{E}{\gamma Z_0}\left[\frac{\cosh \frac{1}{2}\gamma l - 1}{\cosh \frac{1}{2}\gamma l}\right] \quad .. \quad .. \quad (2)$$

Pursuing the analogy with a transmission line, let L, G, be the inductance and leakage conductance per unit length of the conductor. In a buried conductor the resistance and susceptance can be neglected by comparison, respectively, with the reactance and the conductance. Then

$$\gamma \approx (j\omega LG)^{\frac{1}{2}} = (1 + j)(\tfrac{1}{2}\omega LG)^{\frac{1}{2}} \quad .. \quad (3)$$

and

$$\gamma Z_0 = j\omega L \quad .. \quad .. \quad .. \quad (4)$$

The real and imaginary components and the modulus of the bracketed term $[F(\alpha)]$ of equation (2) are plotted in Fig. 2 as a function of $\alpha = \frac{1}{2}l\,(\frac{1}{2}\omega LG)^{\frac{1}{2}}$. The graphs show that when the quantity α exceeds unity, the modulus of $F(\alpha)$ is approximately constant. At a given frequency therefore the current i_c is independent of the conductor length when this length exceeds a certain minimum.

Typical constants for a cable ($\frac{1}{2}$ cm diameter) buried in good agricultural soil are $L = 2\,\mu$H/m, $G = 0{\cdot}001$ mho/m. The capacitance is of order 100 pF/m and can be neglected at frequencies below 500 kc/s. Using these constants the minimum lengths of conductor for which the current at the mid-point is substantially independent of the conductor length are tabulated in Table 1.

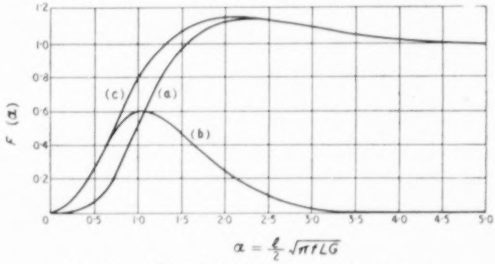

Fig. 2. *Plot of* $F(\alpha) = 1 - \text{sech}\,\alpha(1 + j)$.

TABLE 1

Minimum Length of a Conductor required to Simulate One of Infinite Length

Frequency (kc/s)	Wavelength (metres)	Minimum Length, l_{min} (metres)
10	30,000	300
100	3,000	100
300	1,000	55
1,000	300	30

It will be noted that these lengths are very small compared with the wavelength, particularly at the lower frequencies. For example, at 10 kc/s a conductor 300 metres long would carry nearly the same current at its mid-point as would a conductor of infinite length. This may be regarded as showing that the attenuation in the conductor is high and that disturbances due to reflection at the ends do not persist far along the conductor.

4. Relationship between Induced Current and Frequency

The current induced in a buried conductor depends on a number of frequency-dependent factors, which are discussed below.

(a) The current induced by a vertically-polarized wave depends on the horizontal component of electric field; i.e., on the wave tilt caused by the finite conductivity of the ground. At low frequencies the ratio of the forward component E to the main vertical component E_V is

$$\frac{E}{E_V} = \left(\frac{f}{18j\sigma \times 10^9}\right)^{\frac{1}{2}} \quad .. \quad .. \quad .. \quad (4)$$

where σ is the conductivity of the ground. For good agricultural soil σ is about 0·005 mho/m and

$$E/E_V = 7{\cdot}5(1 - j)f^{\frac{1}{2}} \times 10^{-5} \quad .. \quad (5)$$

The term $(1 - j)$ indicates that the fields differ in phase by 45 degrees.

(b) As the waves penetrate from the surface of the ground to the conductor they are absorbed to an extent dependent on the frequency. The absorption in a depth of 1 metre is small, however, at frequencies below 500 kc/s and it can be assumed that the field at the conductor is equal to that at the surface.

(c) The product of the characteristic impedance and the propagation constant affects the current [see equation (2)] and is $2\pi jfL$ when the resistance of the conductor is negligible.

(d) The ratio of the conductor length to the wavelength is an important factor which has already been discussed and the frequency dependence of the relevant factor may be derived from Fig. 2.

To eliminate one variable, first assume that the conductor is sufficiently long to be considered infinite as regards the current at the mid-point. Then for soil of good conductivity, and assuming that $L = 2\,\mu$H/m,

$$i_c/E_V = 5{\cdot}2(1 + j)f^{\frac{1}{2}} \quad .. \quad .. \quad (6)$$

The modulus of this expression is plotted as curve (a) of Fig. 3. Above 1 Mc/s the curve is approximate because the minimum length necessary to simulate an infinite conductor is no longer a small fraction of the wavelength; the incident field cannot therefore be considered to have uniform phase at all points along the conductor. Also the absorption of the waves in the ground would reduce the current at these frequencies.

Now assume that the conductor is not long enough to appear infinite, and as an example let its length be 200 metres, as used for the experiment described in Section 2. The values plotted on curve (a) in Fig. 3 must be multiplied by factors derived from Fig. 2 by putting $l = 200$. The result of this process is plotted as curve (b) of Fig. 3, which shows that the finite length of the conductor affects the current only at the lowest frequencies. At the higher frequencies a conductor 200 metres long is effectively of infinite length.

Curve (c) of Fig. 3 is a plot of the calculated current at the mid-point of a conductor 200 metres long lying just above the surface of the ground. Comparison with curve (b) shows that the current is reduced by burying the conductor if the frequency is greater than 300 kc/s. With longer conductors the crossover point would occur at a lower frequency.

5. Current near the End of the Conductor

When the cable under consideration serves the direction-finding equipment only, the aerials are usually near the end of the cable. It will be assumed that the buried portion of the cable is sufficiently long to appear semi-infinite. The current at a small distance x from the end may then be derived from equation (1) and is

$$i_x = \frac{Ex}{Z_0} \quad .. \quad .. \quad .. \quad .. \quad .. \quad (7)$$

in which $Z_0 = (j\omega L/G)^{\frac{1}{2}}$ at low frequencies.

Substituting for E from equation (5)

$$\frac{i_x}{E_V} = 7{\cdot}5jx\left(\frac{G}{\pi L}\right)^{\frac{1}{2}} \times 10^{-5} \quad .. \quad .. \quad (8)$$

For the values of the constants already assumed ($G = 0{\cdot}001$ mho/m and $L = 2\,\mu$H/m),

$$i_x/E_V = 0{\cdot}001\,jx \text{ approximately.}$$

This relationship is valid for values of x small compared with the appropriate value of l_{min} quoted in Table 1.

6. Direction Finding Errors caused by Buried Cables

6.1. *Loop Direction Finder near to the Mid-Point of a Conductor*

The bearing error caused by a straight conductor has quadrantal form with zero error in the directions along and normal to the conductor. If the loop-aerial system is near to the conductor the current may be assumed uniform and equal to that at the nearest point.

When the wave is incident at an angle θ to the conductor, in the horizontal plane, the induced current at the mid-point is $i_c \cos\theta$ where i_c is given by equation (2). There is a horizontal component of magnetic field associated with the current at all points not in the horizontal plane through the conductor, and this field may cause errors. If, for example, the observing point is h metres directly above the mid-point the component of field H_2 is, in m.k.s. units,

$$H_2 = \frac{i_c \cos\theta}{2\pi h} \quad .. \quad .. \quad .. \quad .. \quad (9)$$

and is normal to the conductor. The magnetic field H_1 associated with the incident wave is $E_v/120\pi$ and is normal to the plane of incidence. The bearing is determined by the resultant of the two fields H_1, H_2, allowance being made for the phase relationship between them.

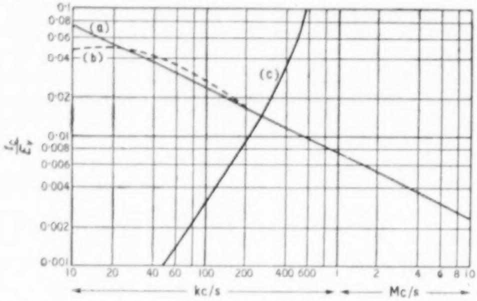

Fig. 3. *Maximum current induced in a conductor; i_c = current at mid-point of the conductor, E_v = vertical electric field in incident wave. (a) Infinitely-long buried conductor; (b) buried conductor 200 m long; (c) conductor 200 m long on the surface of the ground.*

The equations given enable the errors to be calculated and this has been done for the cable which caused the errors plotted in Fig. 1(b). The solid curve in that figure shows these calculated errors; the shape of the curve and the order of magnitude of the errors are in reasonable agreement with the measurements. Closer agreement in respect of amplitude would have been fortuitous because several of the parameters on which the calculations are based are known only approximately. The predominance of positive measured errors is not in agreement with theory and may have been due to the different physical relationships of the two loops to the conductor. It should be noted, however, that if the portion of the conductor near to the aerials were not in line with the rest of the conductor, the error curve would not be symmetrical about the zero-error axis.

6.2 *Loop Direction Finder near the End of a Conductor*

For the present purpose the end of a conductor, such as a power or telephone cable, may be regarded as the point at which it leaves the ground. Provided that the apparatus to which the cable is connected has no earth connection except through the cable, currents flowing in the exposed portion of the cable do so only because of stray capacitance to earth. These stray paths have high impedance at low frequencies.

Now let the co-ordinates of the point of observation be s, d, h, where s is measured along the continuation of the line of the conductor, d horizontally and normal to the conductor, and h vertically. It can be shown that if the current in the conductor is expressed as $AE_vx\cos\theta$, where A is a constant and x is the distance from the end, the horizontal component of the magnetic field due to the current is given by

$$H_2 = \frac{AE_vh}{4\pi\,(d^2+h^2)}\left[\sqrt{d^2+h^2+s^2}-s\right]\cos\theta \qquad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (10)$$

Since the magnetic field of the incident wave is $H_1 = E_v/120\,\pi$,

$$\frac{H_2}{H_1} = \frac{30Ah}{d^2+h^2}\left[\sqrt{d^2+h^2+s^2}-s\right]\cos\theta \qquad \ldots \quad \ldots \quad \ldots \quad (11)$$

A may be derived from Section 5, where it was found that for a thin cable in ground of high conductivity $A = 0{\cdot}001j$. Using this value and taking $\theta = 0$, the modulus (r) of H_2/H_1 has been plotted in Fig. 4 as a series of parabolas in the d-s plane at $h = 1$ metre. For any other angle of arrival $\left|\frac{H_2}{H_1}\right| = r\cos\theta$. Over the end of the conductor ($d = s = 0$) the ratio of the fields is less than 3 per cent. Moreover H_2 and H_1 are in phase quadrature and the secondary field would cause ellipsing of the trace rather than error. The observation techniques used so far are not suitable for detecting the amount of ellipsing involved; in fact, bearings taken near the end of a long telephone cable showed no errors which could be attributed to the cable and no appreciable increase of ellipsing above that caused by other factors. In contrast, errors of nearly 20 degrees were observed over the end of the buried portion of a power cable supplying equipment with separate earth connections; these errors were reduced to less than 5 degrees at a point 3 metres from the cable.

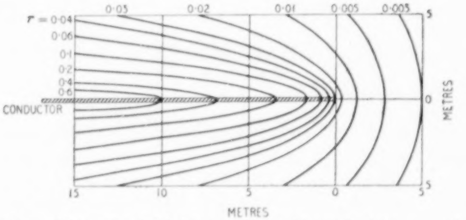

Fig. 4. *Magnetic field due to a straight conductor; r = the amplitude ratio of the horizontal component of the secondary field to that of the incident wave.*

Examination of Fig. 4 shows that as a direction finder is moved along the cable from the end, the error increases rapidly; in the opposite direction there is a corresponding decrease.

If two or more cables terminate at an installation and are laid in different directions it is important that there should be no metallic connection between them, otherwise the equipment is effectively not at the end of a cable. Errors which were observed at one station and which led to the present investigation were found to be due to such a connection. The power cable was laid in a direction 30 degrees removed from that of a disused telephone cable which passed within 2 metres of the aerial system, and the screens were connected. Breaking the connection changed the bearings by 6 degrees at some azimuths.

6.3 *Adcock Direction Finder*

The vertical open aerials of a U-Adcock aerial system are less susceptible than a loop to pick-up from the field of a horizontal conductor, and in general it may be assumed that buried cables have little effect on bearings. With some direction finders operating at 400 kc/s, however, it has been customary for either the power or the telephone cable to be laid in the same trench as one of the aerial feeders and connected to it. This arrangement appears to be prone to errors unless suitable precautions are taken, and discussion of the possible influence of the cables is therefore desirable.

Consider a system in which the aerials are connected to the goniometer by buried screened cables. When a wave is incident in the plane of an aerial pair there is an electric field along the screen of the feeder, given by equation (5). At 400 kc/s, for example, the forward component of field is about 0·07 E_V. Now it is known that large polarization errors may be caused when the system is irradiated by a standard wave, for which a typical ratio of the horizontal to the vertical component of electric field is 0·03. The maximum pick-up from the forward component of a vertically-polarized wave is therefore of the same order of magnitude as that from the horizontally-polarized component of a standard wave, both being measured relative to the maximum pick-up from the vertical component. If the N-S and E-W sections of the aerial system are identical, however, the pick-up from the forward component of field has the same azimuth-dependence as that from the vertical component and no error results. The equality between the aerial pairs may be disturbed by the presence of supply cables, and errors may then occur. For example, if a cable is connected to one aerial feeder throughout its length and then continues outwards the current in the screen of the feeder might be very different from that which would be induced in the absence of the cable.

It is not proposed to study in detail the errors which would occur under these conditions, as they depend on the design of the system, on the precise arrangement of the aerial feeders and on the positions and effectiveness of the earthing points. It can be said, however, that an extended earth system such as is used with many direction finders[5] should reduce any errors to a small magnitude. The extended earth consists of wires laid alongside the aerial feeders and extended outwards for a considerable distance; such an arrangement should ensure that the currents on the aerial feeders are the same for both aerial pairs. The use of an earth mat of the type described by Smith-Rose and Ross[6] should also reduce errors due to cables.

7. Conclusions

The analysis has shown that at low frequencies the currents induced in the screen of a buried cable may be considerably larger than those induced in a similar cable insulated from the ground. Large errors may be caused if a loop direction finder is operated near the cable and at least several metres from either end. If the direction finder is nearer to the end of the cable, as is usual when the cable serves the installation itself, the errors are small provided that there is no good connection to earth from any part of the installation near the aerials. If two cables are laid along different azimuths, their screens should not be connected together, and it is preferable that no metallic connection should exist between the systems to which the inner conductors of the cables are connected (e.g., the direction finder and the telephone apparatus).

Adcock direction finders are less liable to errors from cables than are those using loop aerials, but there is some risk of errors if a cable is laid in close proximity to one aerial feeder. The use of an extended earth system or of an earth mat reduces the risk of errors.

Acknowledgments

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The measurements of bearing errors were made by Mr. V. A. W. Harrison.

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AERIAL RADIATION PATTERNS

Apparatus for Cathode-Ray Tube Display

By T. T. Ling, M.Sc.(Chiao-tung)

(Formerly British Council Research Fellow, University College of Hull)

1. Introduction

IN the course of an investigation upon the variations in the radiation pattern or polar diagram of a 3-cm directive aerial produced by changes in the aerial dimensions, it was found desirable to adopt some method by which the variations could be observed continuously with progressive modifications in the aerial. The well-known, but tedious and lengthy, procedure of carrying field-measuring equipment round the aerial, when used as a radiator, was not appropriate or convenient, while the employment of automatic pen-recording devices[1] was also felt to be less suitable than displaying the pattern upon the screen of a cathode-ray oscillograph.

Although several American publications[2] have depicted c.r.o. displays of radiation patterns, no details have been given in the papers which have so far been available. Furthermore, the photographs reproduced in these publications were not sufficiently clear to justify enlargement in order to use them for quantitative measurements. In one paper[2(b)] it was stated that the aerial under investigation was used as a receiving aerial which was rotated synchronously with magnetic deflecting coils which revolved round the neck of the cathode-ray tube.

Although no new principles are involved, it is felt that the following description of a method for displaying aerial radiation patterns on the screen of an ordinary unmodified cathode-ray oscilloscope may be of some interest. The method was found to be particularly convenient for studying progressive changes in the pattern as structural alterations in the aerial were actually being carried out. By enlarging the pattern at will, so that the main lobe went off the screen, the side-lobes could be examined to any degree of detail required. For more accurate quantitative work, the c.r.o. screen could be photographed, and measurements made on an enlargement.

The method to be described involved using the aerial (the radiation pattern of which was to be investigated), as a revolving receiving aerial actuated by a uniform plane wave from any convenient transmitter.

The chief problem in reproducing the radiation pattern as a c.r.o. display was that of ensuring the faithfulness of the reproduction. This, in turn, depended largely upon the linearity and constancy of the circuit characteristics. There are obviously many ways in which a given signal may be received, detected, amplified and resolved into two components in space quadrature in a form suitable for application to the X and Y deflecting coils (or plates) of a cathode-ray tube. A comparatively long persistent screen is necessary in order that the trace will remain visible at least throughout one revolution of the receiving aerial.

2. Method

The general circuit lay-out finally adopted is shown in the block diagram of Fig. 1. As indicated in the foregoing section, it was decided to use the aerial under investigation as a rotating receiving aerial, consequently any convenient transmitter is suitable for actuating the receiver as long as plane waves are incident upon it. This is assured by maintaining a distance of not less than 250 wavelengths between the transmitting and receiving aerials. The transmitter used is a 3·2-cm cavity magnetron (Type 725) which is pulse-modulated with one microsecond square-topped pulses supplied from a modulator (A.M. Ref. No. 10 DB/956 Type 64) synchronized with the 1,350-c/s supply mains. This modulator also supplies 20-microsecond pulses for triggering a second modulator required for biasing the c.r.t. grid. The radiator consists of a matched horn aerial which points towards the receiver. The power output remains constant throughout the short period (of two seconds and upwards) required to produce the radiation pattern; that is, for one revolution of the receiving aerial. Any serious fluctuation would of course appear as a change in the shape of the display.

The receiving aerial under investigation is mounted on a turn-table capable of rotating at from 1 to 30 r.p.m. The turn-table is driven by a 24-V d.c. motor associated with a speed-control rheostat. The rotor of a magslip (see Fig. 1) is mechanically geared to the turn-table and revolves synchronously with it. The radio-frequency power in the aerial is transmitted through a waveguide and revolving joint to another section of waveguide at the far end of which a thermistor detector is mounted and suitably biased by a 1·5-V battery. This form

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of detector is used because of its linear response to power input.

The modulated high-frequency current, consisting of a series of one microsecond pulses, is transformed by the detector into a series of peaked pulses, each of about 100 microseconds duration, and occurring at the modulation frequency (1,350 c/s). The height of these pulses is proportional to the square of the amplitude of the high-frequency input. These, in turn, are passed through the primary of the input transformer of a very highly-selective audio-frequency amplifier, the bandwidth of which is less than 150 c/s at half amplitude.

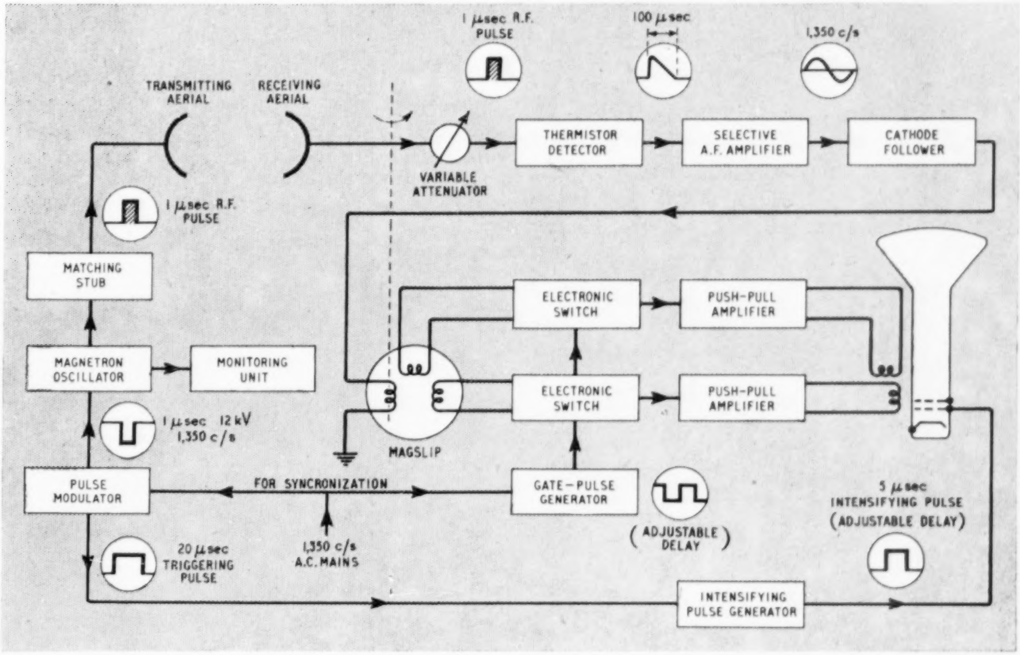
I μsec R.F. PULSE
100 μsec
1,350 c/s
TRANSMITTING AERIAL
RECEIVING AERIAL
THERMISTOR DETECTOR
SELECTIVE A.F. AMPLIFIER
CATHODE FOLLOWER
VARIABLE ATTENUATOR
I μsec R.F. PULSE
MATCHING STUB
ELECTRONIC SWITCH
PUSH-PULL AMPLIFIER
MAGNETRON OSCILLATOR
MONITORING UNIT
ELECTRONIC SWITCH
PUSH-PULL AMPLIFIER
I μsec 12 kV 1,350 c/s
MAGSLIP
PULSE MODULATOR
FOR SYNCRONIZATION
GATE-PULSE GENERATOR
5 μsec INTENSIFYING PULSE (ADJUSTABLE DELAY)
(ADJUSTABLE DELAY)
20 μsec TRIGGERING PULSE
1,350 c/s A.C. MAINS
INTENSIFYING PULSE GENERATOR

Fig. 1. *Block diagram of apparatus for producing aerial radiation pattern.*

The fundamental frequency (1,350 c/s) of the thermistor output pulses is thus converted into a fairly pure sine wave of the same frequency, and of amplitude proportional to the power of the received signal. The selectivity of the amplifier is obtained by using a bridge circuit with negative feedback.

The sinusoidal output is next passed to the rotating primary of a magslip, by way of a cathode follower. The two outputs from the mutually-perpendicular secondaries consist of in-phase sinusoidal waves. These are amplified by the two identical push-pull amplifiers incorporated in the c.r.o., and then fed respectively into the X and Y coils of a magnetically-deflected cathode-ray tube (Oscilloscope Unit Type R78/APS-15A).

It was found desirable to switch the two-push-pull amplifiers on and off electronically by means of gate pulses. The amplifiers are switched on for the first half of a cycle and switched off for the second half of the cycle. This ensures that the cathode-ray trace always starts from a fixed centre. Without the gate-pulse controlled switches, there is a wandering of the centre of the display as the receiving aerial rotates. The gate pulses are obtained by squaring the waveform of the original 1,350-c/s supply mains, the phase being adjusted as necessary by an r.c. network.

The resulting display, when the receiving aerial is stationary, is a straight line radiating outwards from the centre point of the c.r.t. screen, the trace frequency being 1,350 cycles per second. When the aerial rotates, the primary of the magslip rotates synchronously with the result that the linear trace also rotates and sweeps out a luminous area on the c.r.t. screen. The length of the trace depends on the amplitude of the input voltages and these, in turn, depend on the power of the received signal. Thus, with a non-directional rotating receiving aerial and with a long-persistence cathode-ray screen, the display takes the form of a bright circular area, the radius of which is proportional to the received power. With a directional rotating aerial, the bright area takes the shape of the radiation pattern or polar diagram of the aerial.

This presentation would obviously be improved if the bright area could be eliminated so that the perimeter produced by the maximum deflection was alone visible. To do this, the c.r.o. grid must be biased synchronously with the modulation frequency of the transmitter (1,350 c/s), and the spot must only be intensified when the trace is at its maximum. Hence it is essential that the phase of the intensifying pulse should be adjustable.

This is accomplished by using the second modulator referred to above. It is triggered by a 20-μsec pulse supplied from the magnetron modulator (Type 64). The phase-controlled output from the second modulator is then passed to the grid of the c.r.t., and so adjusted that the cathode spot is only intensified when its deflection is a maximum.

A sensitive focusing control and the use of magnetic deflecting coils ensures that the spot is as small as possible. In this way the bright area

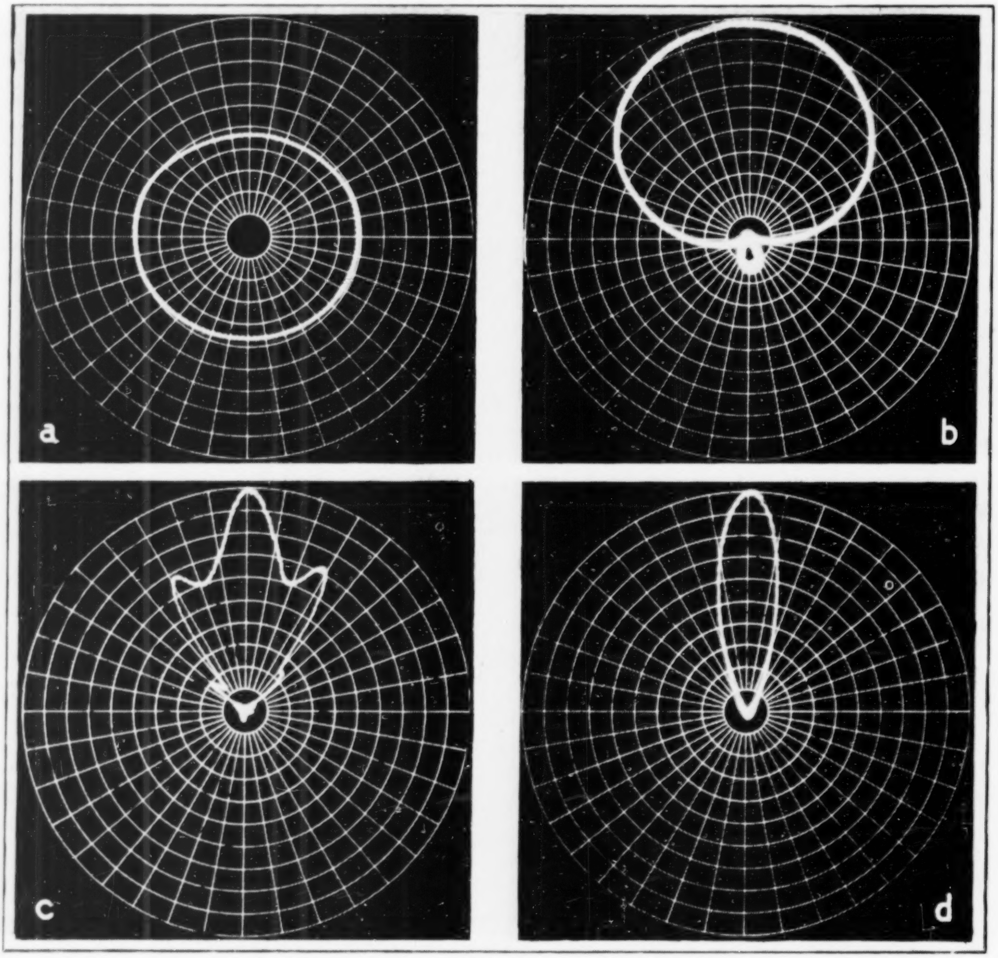

Fig. 2. *Radiation patterns of various aerials taken with the apparatus. That of a* $\lambda/4$ *dipole is shown at* (*a*) *and the effect of adding a parasitic reflector at* (*b*). *The diagram obtained by using the open end of a 3-cm rectangular waveguide as an aerial is shown at* (*c*), *and* (*d*) *illustrates the performance of a matched horn aerial.*

referred to above, which results from a rotating line of varying length, is reduced to a fine bright line traced out by a small spot moving round the perimenter of the radiation pattern. The spot used for the photographs reproduced in Section 3 was not larger than 0·5 mm in diameter. The display could be easily photographed, and enlargements were very suitable for quantitative measurements.

3. Some Results

Fig. 2 shows four typical radiation patterns obtained with the apparatus described above. Fig. 2(a) was obtained by mounting a vertical quarter-wave dipole at the centre of a horizontal brass disc which served as the 'earth'. The disc and dipole were rotated about the axis of the latter. The dipole was a piece of brass wire about three-tenths of an inch in length.

To obtain the polar diagram shown in Fig. 2(b), a quarter-wave dipole, similar in all respects to that described above, was placed on the 'earth' plate parallel to, and about a quarter of a wavelength from the first dipole.

Fig. 2(c) shows the pattern of the radiation emerging from a short horizontal length of rectangular waveguide at the end of which was fixed a vertical flat rectangular brass plate 6 cm in height and 7 cm in width. This plate was responsible for the marked lobes shown in the photograph. In order to obtain this pattern the waveguide was mounted so that it could revolve about a vertical axis lying in the plane of the plate and the open end of the guide.

The polar diagram shown in Fig. 2(d) is that of a rectangular pyramidal horn aerial with an aperture 9 cm by 7½ cm and of axial length 8½ cm. This horn replaced the plate referred to above. The guide with the horn attached was mounted so that its vertical axis of revolution lay in the plane of the horn aperture. The absence of side lobes in this figure is a visual indication of the efficiency of the design of the horn aerial assembly.

Many other patterns have been obtained but these four will serve to indicate the general nature of the displays and the accuracy with which measurements can be made from photographs of the patterns produced by the apparatus described in the previous section.

4. Conclusions

The apparatus in its present form is found to be suitable for quantitative measurements, particularly when it is used in conjunction with a camera and enlarger. The accuracy is determined by the faithfulness of the reproduction of the thermistor detector, amplifiers and c.r.o. response, by the size and the thickness of the line of the display, and by the photographic enlargement system. To obtain a reasonable order of accuracy, these components need not be elaborate. It is felt that with ordinary commercial components, the method is at least as accurate as, and far more rapid than, any other method for polar-diagram measurement.

But the main advantage of the method is that it provides an effectively instantaneous display of the radiation pattern. The complete pattern is produced on the c.r.o. screen in the time taken for the aerial to make one revolution, and this time can be made very short. By contrast, a pen recorder usually takes several minutes to draw a complete pattern. With the c.r.o. display, the effect on the polar diagram of modifying the aerial can be observed at once, and by the person who is actually carrying out the modification. This makes the method particularly suitable for factory adjustments and tests during mass production.

If it is desired to examine small side lobes in detail while still keeping the main pattern in view, a logarithmic amplifier can be inserted between the selective amplifier and the cathode follower. This would change the radius from a linear power scale to a decibel power scale.

If for any reason it is desirable to obtain a cartesian or rectangular display instead of the polar displays shown in Fig. 2, this could be done by arranging for the Y deflection to be proportional to the power intensity while the X deflection would be calibrated in degrees of azimuth. This can be accomplished either by transmitting the position of the varying azimuth of the rotating aerial to the X-deflecting coils by means of two selsyn motors and a phase-sensitive rectifier, or by the use of a sine-cosine potentiometer.

Acknowledgments

The author is very grateful to Professor Palmer for his constant interest and encouragement during the course of development of the apparatus. Thanks are also due to other members of the staff of the Physics Department of the University College of Hull and especially to Dr. A. Cunliffe for valuable discussions.

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SQUIRREL-CAGE FILAMENT STRUCTURES

Equivalent Cathode Diameter

By A. M. Hardie, M.A., B.Sc., A.M.I.E.E.

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SUMMARY.—The solution of problems of space-charge-limited current flow is discussed with particular reference to the squirrel-cage filament structure commonly employed in high-power valves. Experiments are described which were made to determine the solid cathode diameter equivalent to squirrel-cage structures containing an even number of wires up to 16. An example is given of the large error caused in the estimation of valve characteristics by an optimistic assumption of cathode diameter.

1. Introduction

RIGOROUS solutions of space-charge-limited current-flow problems have long been known for cases of planar,[1] cylindrical[2] and spherical symmetry[3] leading to the Child-Langmuir three-halves power law. In these three cases the flow lines are straight or radial and coincident with the direction of the maximum potential gradient, the electron trajectories being normal to the equipotentials.

It may easily be proved dimensionally that the three-halves power law holds for any electrode geometry, but in general it appears to be extremely difficult to obtain solutions for cases in which the trajectories do not cut the equipotentials orthogonally.

In the prediction of valve characteristics from the electrode dimensions it is necessary to know the effective diameter of the filament structure which, in high-power valves, usually takes the form of a squirrel-cage of tungsten wires. The wires are arranged in 'hairpins' connected in parallel so that the currents in adjacent wires flow in opposite directions. This construction reduces the magnetic field of the heating current and thus minimizes magnetron effect[4] on the characteristics. The number of wires is always even and may vary between 4 and 16, while the diameter of the wire very rarely exceeds 0·04 in. in the largest valves.

The grid and anode currents in the space-charge-limited region, neglecting secondary-emission and space-charge modifications, may be estimated from the electrode dimensions provided the effective solid cathode diameter is known. It is clear that the effective diameter must depend mainly on two factors:

(1) The number of wires;
(2) The ratio of the anode diameter (in a diode) to the pitch-circle diameter of the squirrel cage.

In addition to these there must be a dependence on the diameter of the wires, but provided this is small in comparison with the dimensions of the squirrel-cage, the effect may meantime be neglected.

The effective diameter may also depend on anode voltage owing to electron-focusing effects. It is thought, however, that this would normally be small and is not considered further.

If the space-charge-limited current flow for the squirrel-cage configuration could be solved explicitly in the form

$$I = a\,\phi\,(R,\, r,\, N)\; V^{3/2}, \qquad \dots \qquad \dots \qquad (1)$$

where R and r are the anode and wire radii, N the number of wires, and a a constant involving $\sqrt{e/m}$ and depending on the geometry, then the effective cathode diameter could be ascertained by comparing equation (1) with that for current flow in a cylindrical diode having a solid concentric cathode,

$$I = \frac{k\,V^{3/2}}{R\,\beta^2} \qquad \dots \qquad \dots \qquad \dots \qquad \dots \qquad (2)$$

where β^2 is Langmuir's well-known tabulated function and $k = \frac{\sqrt{2}}{9\pi}\sqrt{\frac{e}{m}} = 14{\cdot}68 \times 10^{-6}$.

2. Mathematical Solution

The general problem of current flow between electrodes in the presence of space-charge forces has recently been attacked by Meltzer[5,6] in the reverse sense. Meltzer first formulates the conditions for current flow using vector analysis and then seeks possible solutions, subsequently attempting to fit the electrode geometry to the nature of the flow.

The electron motion is governed by the equation

$$m\,\dot{\boldsymbol{v}} = -e\,\boldsymbol{E}, \qquad \dots \qquad \dots \qquad \dots \qquad (3)$$

$\boldsymbol{v}$ and $\boldsymbol{E}$ being the vector velocity and potential gradient.

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If (following Meltzer's notation) we consider a right-handed Cartesian co-ordinate system with unit vectors $\boldsymbol{I}$, $\boldsymbol{J}$, $\boldsymbol{K}$, then

$$d(v_x) = \boldsymbol{ds} \text{ grad } v_x \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

where $\boldsymbol{ds}$ is a differential displacement in the direction of motion and v_x the x-component of $\boldsymbol{v}$. Hence

$$\dot{v}_x = \boldsymbol{v} \text{ grad } v_x \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

and on substitution in equation (3) of the three components, there results

$$\boldsymbol{I}\,(\boldsymbol{v} \text{ grad } v_x) + \boldsymbol{J}\,(\boldsymbol{v} \text{ grad } v_y) + \boldsymbol{K}\,(\boldsymbol{v} \text{ grad } v_z)$$

$$= -\frac{e}{m}\boldsymbol{E} = \boldsymbol{A}, \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

$\boldsymbol{A}$ being the acceleration vector.

The following relations must also be satisfied:

$$\text{div } (\rho \boldsymbol{v}) = 0 \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

$$\text{div } \boldsymbol{E} = -4\pi\rho \quad \ldots \quad \ldots \quad (8)$$

$$\boldsymbol{E} = -\text{grad } V \quad \ldots \quad \ldots \quad (9)$$

where ρ and V are respectively the charge density and potential.

Meltzer then chooses values of v_x, v_y and v_z which are functions of the co-ordinates x, y and z containing arbitrary parameters which are adjusted to satisfy the conditions

$$\text{curl } \boldsymbol{A} = 0 \quad \ldots \quad \ldots \quad \ldots \quad (10)$$

$$\text{and div } (\boldsymbol{v} \text{ div } \boldsymbol{A}) = 0 \quad \ldots \quad \ldots \quad \ldots \quad (11)$$

In a later paper[6] Meltzer deduces other conditions applicable to space-charge flow which may in some instances be easier to apply.

Walker[7] approaches the problem from the hydrodynamical viewpoint employing the action function, and proceeds to solve the case of two inclined plane electrodes, one of which is the emitter. This case has also recently been treated by Ivey[8] in greater detail.

If we commence with a given cathode structure, however, such as the squirrel-cage, or a planar grid of wires, we find that the equations cannot be integrated. As far as the author knows, no solution has yet been published even for the cylindrical diode with an eccentric cylindrical cathode.

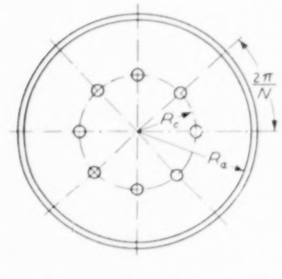

Fig. 1. *Section of diode with squirrel-cage cathode.*

Referring to Fig. 1, we have the following equations on the assumption of cylindrical symmetry:

$$\frac{\partial^2 V}{\partial r^2} + \frac{1}{r}\frac{\partial V}{\partial r} + \frac{1}{r^2}\frac{\partial^2 V}{\partial \theta^2} = -4\pi\rho \quad \ldots \quad (12)$$

If v_r and v_t are the radial and tangential velocity components,

$$\frac{\partial v_r}{\partial t} = \frac{e}{m} \cdot \frac{\partial V}{\partial r}, \quad \ldots \quad \ldots \quad \ldots \quad (13)$$

$$\frac{\partial v_r}{\partial t} = \frac{e}{m} \cdot \frac{1}{r} \cdot \frac{\partial V}{\partial \theta}. \quad \ldots \quad \ldots \quad \ldots \quad (14)$$

$$\text{Also} \quad J_r = \rho v_r, \quad \ldots \quad \ldots \quad \ldots \quad (15)$$

$$J_t = \rho v_t, \quad \ldots \quad \ldots \quad \ldots \quad (16)$$

J_r and J_t being the components of current density.

We may assume a solution of the form

$$J = f\,(r,\, \theta)\; b\, V^{3/2}, \quad \ldots \quad \ldots \quad \ldots \quad (17)$$

where $f\,(r,\,\theta)$ is a function to be determined and b a numeric including $\sqrt{e/m}$.

The boundary conditions are complicated by the finite diameter of the filament wires, but if the cross-section of a wire is treated as a point, we can state that $V = V_a$ when $r = R_a$ and $V = 0$ when $r = R_c$, $\theta = 2\kappa\pi/N$, κ taking integral values from 0 to N. This assumption leads to infinite current density at the wires.

Since there can be no circulation of current we also have

$$\int_0^{2\pi} J_t \, d\theta = 0 \quad \text{or} \int_0^{\frac{2\pi}{N}} J_t \, d\theta = 0$$

since the solution must be periodic from the symmetry of the structure and there can be no current flow normal to a diameter bisecting any filament wire.

The total current is then found by integrating J round the anode.

A solution to this problem has not yet been found.

3. Solution of Space-Charge Problems by Electrical Analogies

In default of a relaxation method applied to a series of cathodes having different numbers of wires N and a number of anodes of varying diameter, it is theoretically possible to obtain a series of numerical solutions by the resistor-network analogy as developed by Liebmann[9,10] which is capable of application to space-charge problems, and by the method of Musson-Genon[11,12] using the electrolytic tank with a 'modulated' bottom to take account of space-charge. Both these methods work by successive approximations and in this application would be exceedingly tedious to carry out over a number of cases sufficient to derive a general formula.

4. Direct Experimental Method

In order to obtain a partial solution to the problem of the effective diameter of the squirrel-cage cathode over a restricted range a series of experiments was undertaken using a continuously-evacuated demountable diode.

Let there be available a number of anodes of different diameters, D_1, D_2, . . ., etc., and a series of squirrel-cage cathodes of constant R_c (Fig. 1) and varying N. We may easily calculate the space-charge-limited current I_0 at a certain anode voltage V_a for a cylindrical diode having a solid cathode of radius R_c. If we now measure I at the same anode voltage V_a for the series of cathodes successively inserted in the anode of diameter D_1, we may plot a series of points showing I versus N for D_1 and the curve joining them must approach the I_0-line for D_1 [Fig. 2(a)]. Repeating this process for anodes of increasing diameter D_2, D_3, . . ., etc., at the same anode voltage, a family of curves will be obtained, each successive curve exhibiting a more rapid approach to the corresponding I_0-line.

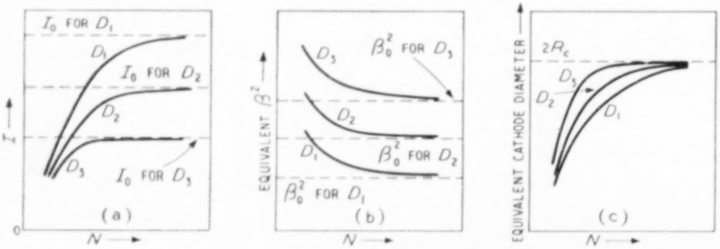

Fig. 2. (above). *Curves showing expected variation of current (a), 'equivalent β^2' (b), and equivalent cathode diameter (c) as a function of the number of cathode wires and for various anode diameters.*

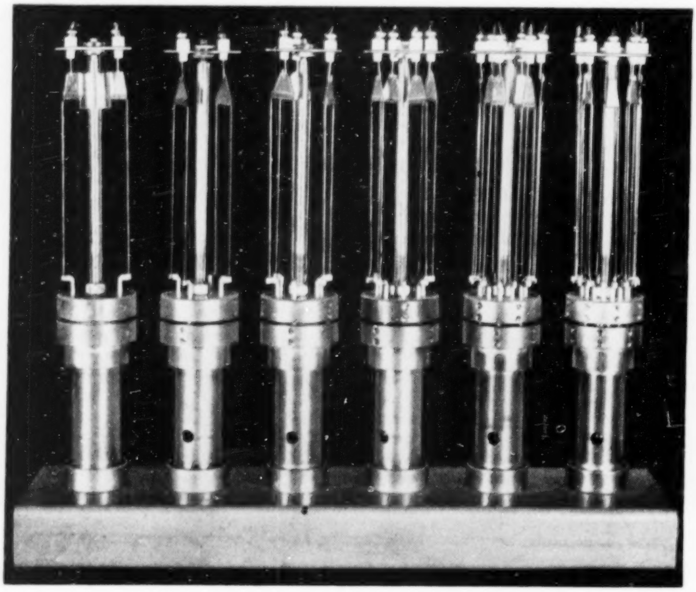

Fig. 3. (right). *Series of demountable filament assemblies (mounted in carrying stand).*

It is clear that if N is very large the effective cathode diameter will be indistinguishable from the diameter of the squirrel-cage, since in the limit this becomes a solid cylinder.

If N is fixed we should expect a more rapid approach to the I_0-line for a larger diameter anode; i.e., as N is increased the effective cathode diameter should approach the limiting value more rapidly for a larger anode diameter. This may be loosely expressed by remarking that a given cathode structure appears more solid to a larger anode.

If the currents for the various N values are now substituted in equation (2), values of 'equivalent β^2' may be computed, giving a family of 'equivalent β^2' curves with D as parameter. Each member of the family will approach its corresponding β^2_0-line, β^2_0 being the value of β^2 for the solid cathode corresponding to I_0 [Fig. 2(b)].

Since R_a/R_c is known, the final result may be expressed as an equivalent diameter in terms of R_c [Fig. 2(c)].

Provided sufficient experimental data were available it would appear possible to construct satisfactory design curves covering the normal working range of R_a/R_c and to make reasonably close interpolations.

Apparatus

Six filament assemblies were made (Fig. 3) having 2, 4, 6, 8, 12 and 16 strands of 0·008-in. diameter tungsten wire arranged in the form of 'hairpins' on a 1-in. diameter pitch-circle. The 'hairpins' are supported by spring-loaded molybdenum cradles so that all the filaments are parallel and the cradle suspensions are insulated from their supporting molybdenum disc by small silica bushes. A central molybdenum rod, tapped into the copper body of the assembly, supports the filaments. The sectional drawing of Fig. 4 shows the coaxial construction of the copper body and its connection with the two cathode flanges from which the current leads are taken. These flanges are separated by a silica spacing ring to which they are sealed by Apiezon wax.

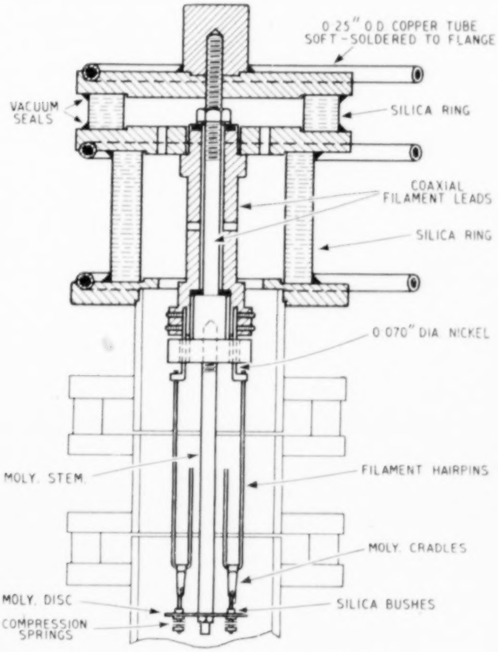

Fig. 4. *Filament assembly.*

Three demountable copper anode assemblies were designed on the guard ring principle, so that current measurement can be made over the central region of the filament at uniform temperature and in an electric field free from end effects.

The central and guard anodes are separated by silica rings so that the annular anode gaps are 0·0625 in., while the anode diameters are 1·47, 1·95 and 2·75 in. and all are water-cooled.

Each anode assembly is a semi-permanent structure and is used in conjunction with each cathode in turn. Only three demountable joints are required: one sealing the lower cathode flange to the silica pot and the latter to the upper anode flange. When changing a cathode only the top seal need be broken, the whole filament assembly with its two flanges removed, the body unscrewed from the flanges and the next cathode inserted. To ensure correct alignment the lower cathode flange and upper anode flange were machined to fit the internal diameter of the supporting silica pot.

The anodes are assembled on a mandrel under vacuum and the various flanges sealed to their silica spacing rings by Apiezon wax. This sets hard on cooling and makes a semi-permanent seal. The three demountable joints are made with Apiezon Q compound. Fig. 5 shows a complete diode assembled for operation on the diffusion pump. A flap valve is used between the pump and the diode so that the vacuum can be broken and a cathode quickly changed without stopping the pumps.

A circuit diagram of the diode and supplies is given in Fig. 6.

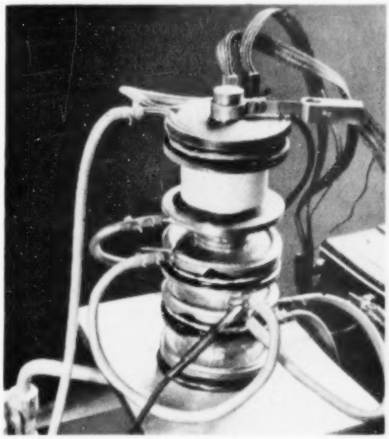

Fig. 5. *Demountable diode assembled for operation on vacuum pump.*

Experimental Results

From the tables of Langmuir and Jones[13] the required heating current and saturated emission of the filaments were calculated for an operating temperature of 2,600°K and are given in Table 1. The figures for saturated emission are those which would be measured over the length of the central anode.

TABLE 1

No. of wires (N)	No. of hairpins	Heating current (A) $T = 2{,}600°K$	Sat. emission (A) $T = 2{,}600°K$
1	—	4·7	0·174
2	1	4·7	0·348
4	2	9·4	0·696
6	3	14·1	1·044
8	4	18·8	1·392
12	6	28·2	2·088
16	8	37·6	2·784

The theoretical emission currents for one central filament wire 0·008-in. diameter and for a solid cathode 1-in. diameter were next determined for each of the three anode diameters at an anode voltage of 200 V, this value being chosen for all current measurements since it gave an emission current well below saturation for the smallest number of filament wires; i.e., $N = 2$. These values of I_0 and the corresponding values of β^2_0 are given in Table 2.

After preliminary outgassing of the filament assemblies, emission curves were taken. These are shown as the three families of Fig. 7(a), (b) and (c). No current readings were taken after the insertion of a cathode until the emission current remained constant at any given anode voltage for at least 15 minutes, while in all cases readings were repeatable once stable conditions had been attained.

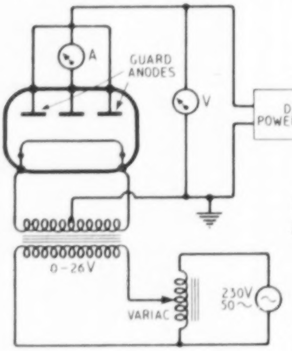

Fig. 6. *Circuit diagram of demountable diode and supplies.*

It will be observed that the theoretical value of I_0 for the solid cathode is closely approached as N increases towards 16 and that the agreement between the experimental trend and the calculated values of I_0 is good. I is plotted against N at $V_a = 200$ in Fig. 8, which exhibits the family of curves corresponding to the predictions of Fig. 2(a).

Curves of 'equivalent β^2' computed from the values of Fig. 8 are shown in Fig. 9 which illustrates the corresponding approach to the β^2_0-

TABLE 2

Anode Diameter (in.)	Emission Current (mA) (Calc.)		β^2_0 for Solid Cathode
	Single Wire 0·008-in. dia. $V_a = 200$ V	Solid Cathode 1-in dia. (I_0) $V_a = 200$ V	
1·47	84·5	753	0·113
1·95	63·7	238	0·269
2·75	45·1	98	0·463

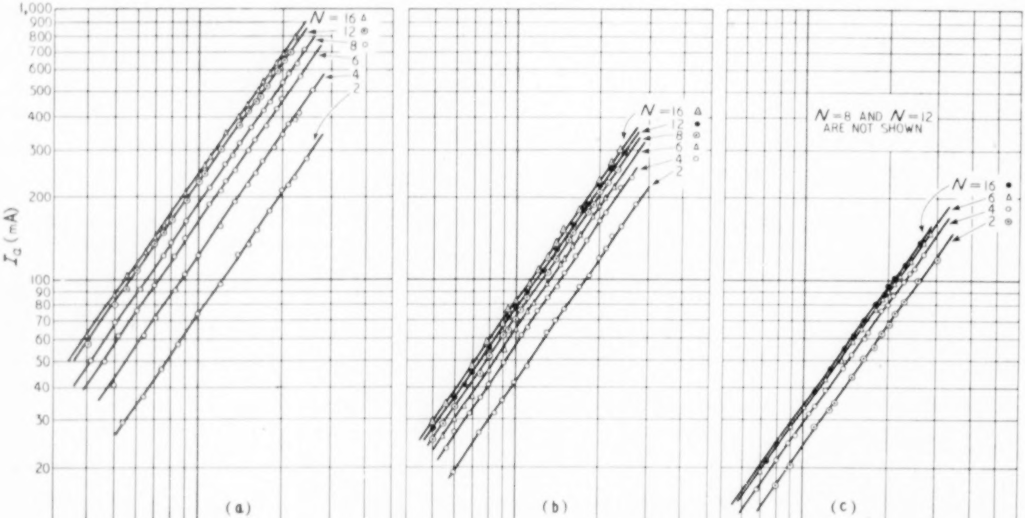

Fig. 7. *Emission for anode diameters of* 1·47 *in.* (*a*), 1·95 *in.* (*b*) *and* 2·75 *in.* (*c*). *In the last, the curves for* $N = 8$ *and* $N = 12$ *are not shown.*

line for the solid cathode. The leading figures are given in Table 3 while the equivalent solid cathode diameter plotted against N is shown in Fig. 10.

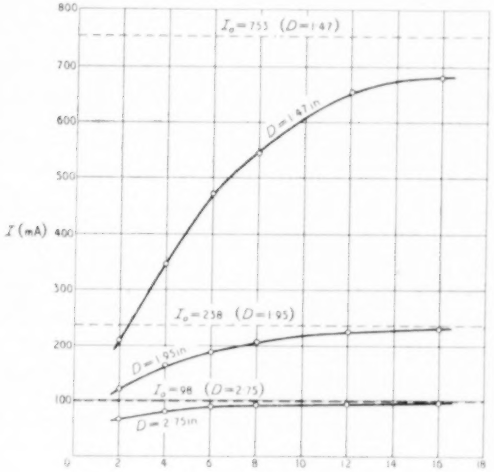

Fig. 8. *Variation of current with N deduced from the curves of Fig. 7.*

5. Application of Experimental Results

The experimental results are now used in the estimation of triode characteristics, and the predicted electrode currents are then compared with those obtained by a pulse method[14] in the positive grid region.

The valve used for this work was the Ediswan Type EAT 1500, a medium-power forced-air-cooled triode having a thoriated-tungsten filament. At the time these experiments were made, only short-electrode valves were available, and the EAT 1500 was chosen on account of its having a thoriated filament and the consequent absence of the early saturation effects which are evident in the characteristics of a short valve having a pure tungsten filament subjected to considerable end-cooling. It was desirable to use a valve having a 4-filament cathode (i.e., $N = 4$), in order to show clearly the error in the predicted characteristics which results from an optimistic assumption of effective cathode diameter. The particulars of the EAT 1500 are given in Table 4.

TABLE 3

Anode Dia. (in).	N	I (mA)	Equivalent β^2	Equivalent Solid Cathode Diameter ($\times 2R_c$)
1·47	2	210	0·405	0·595
	4	345	0·246	0·78
	6	470	0·181	0·87
	8	545	0·156	0·91
	12	658	0·129	0·96
	16	680	0·125	0·97
1·95	2	120	0·532	0·63
	4	164	0·390	0·81
	6	188	0·340	0·88
	8	207	0·308	0·93
	12	225	0·284	0·97
	16	230	0·278	0·98
2·75	2	68	0·666	0·69
	4	82	0·552	0·86
	6	92	0·492	0·96
	8	94	0·482	0·98
	12	95	0·477	0·98
	16	96	0·472	0·99

TABLE 4

Triode Type EAT 1500—Electrode Dimensions

Anode Diameter	34·5 mm
Grid Diameter (Mandrel) ..	15 mm
Grid Wire Diameter (Tungsten Helix)..	0·266 mm
Grid Pitch	2·325 mm
No. of Grid Supports	4
Diameter of Grid Supports ..	2·18 mm (1·78-mm dia. molybdenum over-wound with 0·20-mm molybdenum wire)
Active length of electrodes ..	85 mm
No. of Filaments	4
Pitch-circle Diameter of Filaments	10 mm
Filament Wire Diameter ..	0·56 mm
Amplification Factor	27 (Manufacturer's Figure)

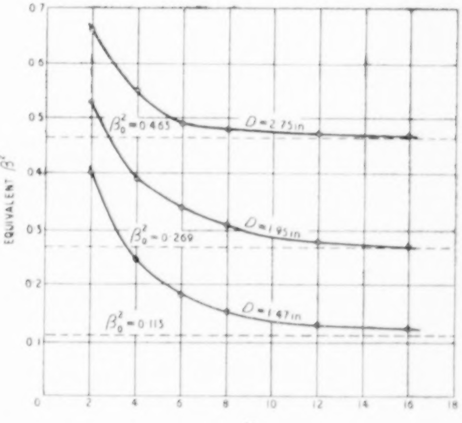

Fig. 9. *Curves of 'equivalent β^2'.*

Calculation of Electrode Currents

The electrode currents in a triode may be derived with sufficient accuracy for our purpose by using the concept of the equivalent diode. This assumes that a diode may be constructed which has the same current-voltage relationship as a given triode and relies on the experimental fact that over a restricted range the cathode current of a triode is very nearly given by

$$I = K\left(V_g + \frac{V_a}{\mu}\right)^{3/2}; \quad \dots \quad \dots \quad (18)$$

where K is a constant which is to be determined.

The logic of the approach to the concept of the equivalent diode has been the subject of much controversy[15] and reference may be made to the literature for a full account. We now employ an artifice due to Fremlin[16] in order to evaluate the constant K.

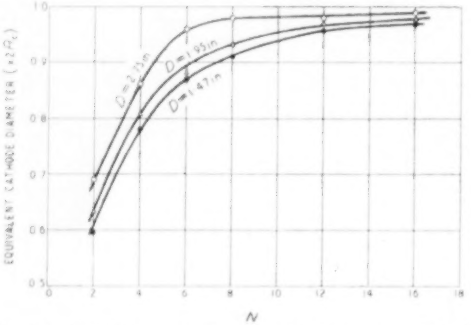

Fig. 10. *Variation of equivalent cathode diameter with N.*

Consider a triode which has been temporarily deprived of its grid and in which a space-charge-limited current, I, flows at anode potential V_a. The current is given by

$$I = \frac{kV_a^{3/2}}{R_a\beta^2_{ca}} \text{ A/cm}, \quad \dots \quad \dots \quad \dots \quad (19)$$

in which β^2_{ca} is determined from the ratio of anode to cathode radii.

The potential distribution in the anode-cathode space is calculable and the potential at the location of the extracted grid can therefore be determined. If the grid, supposed to be fashioned from extremely fine wire, is now replaced at this potential in its proper location, the potential distribution remains undisturbed and the current unchanged. For this condition the current is given by

$$I = \frac{kV_g^{3/2}}{R_g\beta^2_{cg}} \quad \text{A/cm}, \quad \dots \quad \dots \quad \dots \quad (20)$$

in which V_g is the appropriate grid potential and β^2_{cg} is determined from the ratio of grid to cathode radius. From equations (19) and (20) we obtain

$$V_a = \frac{I^{2/3}(R_a\beta^2_{ca})^{2/3}}{k^{2/3}}, \quad \dots \quad \dots \quad \dots \quad (21)$$

and

$$V_g = \frac{I^{2/3}(R_g\beta^2_{cg})^{2/3}}{k^{2/3}}. \quad \dots \quad \dots \quad \dots \quad (22)$$

On substitution of (21) and (22) in (18), this becomes

$$I = \frac{K}{k}\left\{I^{2/3}(R_g\beta^2_{cg})^{2/3} + \frac{1}{\mu}I^{2/3}(R_a\beta^2_{ca})^{2/3}\right\}^{3/2}, \quad (23)$$

$$\text{whence } K = \frac{k}{\left\{(R_g\beta^2_{cg})^{2/3} + \frac{1}{\mu}(R_a\beta^2_{ca})^{2/3}\right\}^{3/2}},$$

$$\text{i.e., } K = \frac{k}{R_g\beta^2_{cg}\left\{1 + \frac{1}{\mu}\left(\frac{R_a\beta^2_{ca}}{R_g\beta^2_{cg}}\right)^{2/3}\right\}^{3/2}}, \quad (24)$$

$$\text{and} \qquad I = \frac{k}{D}\left(V_g + \frac{V_a}{\mu}\right)^{3/2} \text{ A/cm}, \quad \dots \quad (25)$$

where D is the denominator of equation (24).

In the positive grid region $I = I_a + I_g$, and if I_a and I_g are to be separately determined it becomes necessary to estimate their ratio. In the absence of secondary emission from the electrodes this may be done by employing the current-division relationship

$$\frac{I_a}{I_g} = \delta\left(\frac{V_a}{V_g}\right)^{\frac{1}{2}}, \quad \dots \quad \dots \quad \dots \quad (26)$$

δ being the current division factor which may be found by setting $V_a = V_g$. Spangenberg[17] has derived an expression for δ applicable to planar triodes which is approximately true for cylindrical structures if the diameters of the electrodes are large in comparison with their spacing. We shall assume here, however, that $\delta = 1/S$, where S is the 'screening fraction' or 'shadow ratio' of the grid; i.e., the fraction of the area of the active grid cylinder occupied by the grid wire and supports.

On substituting for I_g in equation (25) we obtain the anode current

$$I_a = \frac{k}{D}\frac{\left\{V_g + \frac{V_a}{\mu}\right\}^{3/2}}{1 + S\left(\frac{V_g}{V_a}\right)^{\frac{1}{2}}} \text{ . A/cm} \quad \dots \quad (27)$$

The mutual conductance, g_m, may now be determined by differentiating equation (27) with respect to V_g, so that

$$g_m = \frac{3}{2}\frac{k}{D}\frac{(1 + 1/\mu)}{(1 + S)^2}\left\{1 + S\left(\frac{V_g}{V_a}\right)^{\frac{1}{2}} - \frac{S}{3}\frac{(V_g + V_a/\mu)}{(V_gV_a)^{\frac{1}{2}}}\right\} \text{ . A/V/cm.} \quad \dots \quad \dots \quad \dots \quad \dots \quad (28)$$

The foregoing calculation neglects the effects of secondary emission from the electrode surfaces which is usually evident in the positive grid region. The effect of secondary emission is observed as an increase in grid current when $V_a < V_g$, and a decrease when $V_a > V_g$, with corresponding opposite changes in anode current. When $V_a = V_g$ there is practically no potential gradient in the grid-anode space and secondaries tend to fall back into the electrodes producing them, so that I_a and I_g measured under this condition are close to the true primary values when secondary emission is absent.

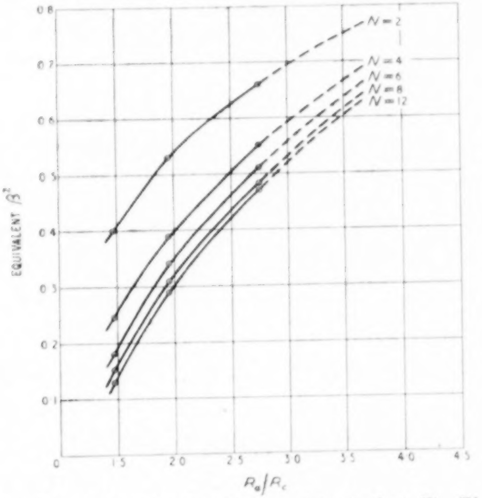

Fig. 11. *Relation between R_a/R_c and 'equivalent β^2'. The curves are extrapolated at the higher values.*

In order to apply the experimental results it is necessary to replot Fig. 9 in the form 'equivalent β^2' versus R_a/R_c as a family of curves with N as parameter. This has been done in Fig. 11 and the curves extrapolated to $R_a/R_c = 3{\cdot}5$. Although each curve is constructed from only three points, the trend of the family is sufficiently evident to render such extrapolation possible in the absence of further experimental data. This is necessary on the curve $N = 4$ since R_a/R_c for the Type EAT 1500 triode has the value 3·45.

The I_a characteristics of Fig. 12 are calculated from equation (27) and the I_g characteristics from the current-division relationship (26). The experimental points obtained by pulse technique are in reasonable agreement with the calculated I_a curves but exhibit greater divergence from the I_g characteristics. The presence of secondary emission is evident from the crossing of the calculated characteristics by the experimental points as V_a increases, accompanied by a sympathetic increase in I_a in corresponding regions.

Table 5 has been drawn up in order that comparison may be made between the leading figures in the calculation of I_a and I_g using (a) values of 'equivalent β^2' obtained from Fig. 11, and (b)

TABLE 5

	(a) Using equivalent solid cathode diameter	(b) Using pitch-circle diameter of filament wires
β^2_{ca}	0·660	0·593
β^2_{cg}	0·255	0·119
$R_g\beta^2_{cg}$	0·192	0·089
$R_a\beta^2_{ca}$	1·137	1·022
$R_a\beta^2_{ca}/R_g\beta^2_{cg}$	5·93	11·48
D	0·228	0·115
$\dfrac{h}{D}$	$0{\cdot}644 \times 10^{-4}$	$1{\cdot}27 \times 10^{-4}$

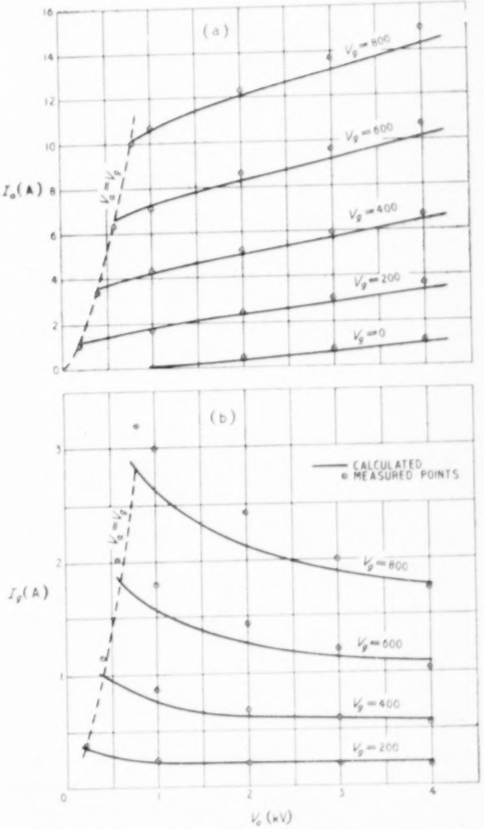

Fig. 12. *The curves show the calculated valve characteristics while the ringed points indicate measured values. They represent the anode (a) and grid (b) current characteristics of the EAT 1500 valve.*

values of β^2 using the pitch-circle diameter of the filament wires as the cathode diameter.

Both I_a and I_g are proportional to the factor k/D [equation (27)]. If the cathode diameter is assumed equal to the pitch-circle diameter of the wires the currents are 1·98 times greater than those obtained using 'equivalent β^2' values resulting from a smaller effective cathode diameter.

6. Conclusion

While insufficient experimental data have so far been gathered to solve the equivalent-cathode problem completely, it is felt that the work described above may contribute something to design practice and perhaps form a basis for judicious interpolation.

Although the direct experimental method using a demountable diode with interchangeable filaments is probably the easiest for preliminary work, it becomes both tedious and difficult if an attempt is made to account for variations of filament wire diameter and focusing effects—tedious because of the large number of different filament structures and anode diameters required, and difficult because of the masking of small variations by experimental inaccuracies.

It appears, however, that indirect methods such as the resistor network and the electrolytic tank would be even more time-consuming, involving field-plotting and tracing of electron trajectories for each case, and owing to accumulated inaccuracies the final results might be seriously in error.

Acknowledgment

The work was carried out in the Research Laboratories of Metropolitan Vickers Electrical Co., Ltd., Trafford Park, Manchester. Grateful acknowledgment is made to Dr. C. Dannatt, O.B.E., D.Sc., Director of Research, and to Mr. B. G. Churcher, M.Sc., M.I.E.E., Manager of Research Department, for permission to publish this paper.

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NEW H.F. PROXIMITY-EFFECT FORMULA

By A. C. Sim

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SUMMARY.—Accurate formulae for the high-frequency resistance and inductance of a pair of parallel circular conductors connected in series have been presented in the past, but they are all very complicated. The present work derives a new asymptotic formula which is valid whenever the effect is so severe that the resistance is more than doubled. The formula is rigorous and very simple, and has been derived by means of a new approach to the problem.

1. Introduction

SINCE the first, and very exhaustive, analysis of the problem by G. Mie[1] in 1900 a large number of papers has been published, most of which ignore previous work and, in consequence, arrive at formulae possessing severe limitations. Arnold,[2] however, surveyed this work, selected Butterworth's solution[3] as the most fruitful, and proceeded to extend and develop it. The result has been the presentation[4,5] of a formula which is valid and accurate over the entire physical range of the problem.

The need for a further investigation of the problem is evident from the complexity of Arnold's formula. A new formula, even though it may not be valid for all possible cases, can be of value, if it is really simple and its range of validity is readily found.

Previous workers in the field have either employed Maxwell's equations, or used an integral equation. The present author has found that the amalgamation of both approaches leads most readily to a final result, and the method is, moreover, easily extended to other related but more difficult problems.

In addition it has been found that the general

MS accepted by the Editor, December 1952

resistance formula obtained by means of Poynting's theorem, which has been universally employed in the past, necessitates a large amount of unnecessary algebraical and analytical labour. The author has developed a new impedance equation which leads more directly to the final result, and without which the new formula to be presented would have been difficult to derive.

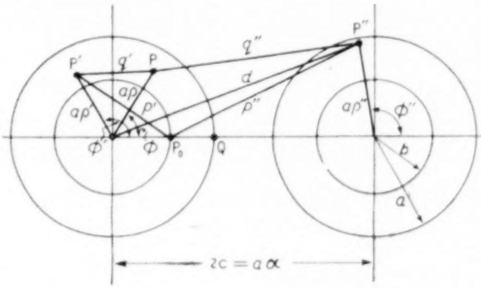


Fig. 1. *Section through two parallel conductors with the geometrical construction used in the analysis.*

2. Impedance Formula

From the symmetry of the problem only the field components $\mathcal{E}_z$, H_ρ, H_ϕ, will exist provided displacement currents are negligible. If ρ is a dimensionless radial co-ordinate, $\rho = r/a$ where a is the outer radius of the conductors and r is an arbitrary radius, and if ϕ is an angular co-ordinate (Fig. 1), and ξ is a parameter defined by

$$\xi^2 = j\omega\mu\sigma a^2 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

where ω is the angular frequency of the current, μ the permeability of the conductors and the medium surrounding them, and σ is the conductivity of the conductors, all in rationalized m.k.s. units; then a solution of Maxwell's equations shows that the electric field can be expressed in the form:

$$\mathcal{E}_z = \sum_{n=0}^{\infty} \left[M_n \mathrm{I}_n(\xi\rho) + M_n' \mathrm{K}_n(\xi\rho)\right] \cos(n\phi) \ldots (2)$$

where M_n and M_n' are constants of integration, and I_n and K_n are the modified Bessel functions. The magnetic field can be found from $\mathcal{E}_z$ by means of Maxwell's equations:—

$$H_\rho = \frac{j}{\mu\omega a\rho}\frac{\partial \mathcal{E}_z}{\partial \phi}, \text{ and } H_\phi = \frac{-j}{\mu\omega a}\frac{\partial \mathcal{E}_z}{\partial \rho} \quad \ldots (3)$$

If, in Fig. 1, P' and P'' are roving points in each conductor with co-ordinates ρ', ϕ' and ρ'', ϕ''; and p', q' and p'', q'' are the corresponding distances indicated in the diagram, then Curtis's[6] integral equation as modified by Manneback,[7] shows that the electric field must also satisfy the equation:

$$\mathcal{E}_z = \left\{\mathcal{E}_0 - \frac{\xi^2}{2\pi}\int_k^1\int_0^{2\pi} \rho'\mathcal{E}_z' \log(p'/q')\,d\rho'\,d\phi' + \frac{\xi^2}{2\pi}\int_k^1\int_0^{2\pi} \rho''\mathcal{E}_z'' \log(p''/q'')\,d\rho''\,d\phi''\right\} \quad \ldots \quad \ldots \quad \ldots (4)$$

where $\mathcal{E}_0$ is the value of $\mathcal{E}_z$ at the point P$_0$, $\mathcal{E}_z'$ and $\mathcal{E}_z''$ the values at P' and P'', and $k = b/a$ is the ratio of inner to outer radii.

By substituting the series (2) into equation (4), the constants M_n and M_n' can be determined, and it is found that the value of $\mathcal{E}_z$ at the point Q is given by

$$\mathcal{E}_z = I R_0 \frac{\xi^2}{2}\left\{\chi_0 + \sum_{n=1}^{\infty}\frac{\alpha^n A_n}{n}(1+\chi_n)\right\} \quad (\rho = 1, \phi = 0) \quad \ldots \quad \ldots \quad \ldots (5)$$

where $R_0 = 1/\pi\sigma a^2$, I is the total current, and the constants A_n are defined by

$$A_n = \left\{1 + \sum_{m=1}^{\infty}\binom{n+m-1}{m}\alpha^{2m}\chi_m A_m\right\} \quad (6)$$

where $\binom{n}{m} = \dfrac{n!}{(n-m)!m!}$ is the binomial coefficient,

$$\chi_n = \left\{\frac{\mathrm{I}_{n+1}(\xi)\,\mathrm{K}_{n+1}(k\xi) - \mathrm{I}_{n+1}(k\xi)\,\mathrm{K}_{n+1}(\xi)}{\mathrm{I}_{n-1}(\xi)\,\mathrm{K}_{n+1}(k\xi) - \mathrm{I}_{n+1}(k\xi)\,\mathrm{K}_{n-1}(\xi)}\right\}$$

and

$$\chi_0 = \left\{\frac{\mathrm{I}_0(\xi)\mathrm{K}_1(k\xi) + \mathrm{I}_1(k\xi)\mathrm{K}_0(\xi)}{\mathrm{I}_1(\xi)\mathrm{K}_1(k\xi) - \mathrm{I}_1(k\xi)\mathrm{K}_1(\xi)}\right\}\Big/\xi \quad \ldots \quad (7)$$

Similarly the magnetic intensity perpendicular to the plane containing the conductor axes, and external to the conductor is found to be

$$H_\phi = \frac{I}{2\pi a}\left\{\rho^{-1} + \sum_{n=1}^{\infty}\alpha^n A_n\left[\rho^{(n-1)} + \rho^{-(n+1)}\chi_n\right]\right\} \quad (\rho > 1, \phi = 0) \quad \ldots (8)$$

Thus the flux linking the point Q, which must equal half the flux passing between the conductors, is

$$\Phi = \mu a\int_1^{\alpha/2} H_\phi\,d\rho = \frac{\mu I}{2\pi}\left\{\log(1/2\alpha) + \sum_{n=1}^{\infty}\frac{\alpha^n A_n}{n}\left[1-(2\alpha)^n\right]\left[\chi_n + (2\alpha)^{-n}\right]\right\} \quad (9)$$

The total voltage drop at Q must be $(\mathcal{E}_z + j\omega\Phi)$ per unit length of conductor, and this must be half the applied voltage per unit length of the system. It follows that the impedance per unit length is

$$Z = R_0\xi^2\left\{\chi_0 + \log(1/2\alpha) + \sum_{n=1}^{\infty}\frac{A_n}{n}\left[2^{-n} - (2\alpha^2)^n\chi_n\right]\right\} \quad \ldots (10)$$

Now, from Equ. (6), if x is an arbitrary variable sufficiently small,

$$\sum_{n=1}^{\infty} \frac{x^n A_n}{n} = \Bigg\{ -\log(1-x) + \sum_{n=1}^{\infty} \sum_{m=1}^{\infty} \binom{n+m-1}{m} \frac{x^n \alpha^{2m}}{n} \chi_m A_m \Bigg\}$$

$$= \Bigg\{ -\log(1-x) + \sum_{m=1}^{\infty} \sum_{n=1}^{\infty} \binom{m+n-1}{n} \frac{x^n \alpha^{2m}}{m} \chi_m A_m \Bigg\}$$

$$= \Bigg\{ -\log(1-x) + \sum_{m=1}^{\infty} \left[1-(1-x)^{-m}\right] \frac{\alpha^{2m}}{m} \chi_m A_m \Bigg\} \quad . . (11)$$

By letting $x = 1/2$, and substituting the result into equation (10), there follows:

$$Z = R_0 \xi^2 \left\{ \chi_0 + \log(1/\alpha) - \sum_{m=1}^{\infty} \frac{\alpha^{2m}}{m} \chi_m A_m \right\} \quad . . (12)$$

It can be seen from Equ. (6) that this series is identical with the coefficient of n in the expansion of A_n in powers of n, and it follows that if

$$A_n = \kappa^n \{1 + n.\kappa_1 + n^2.\kappa_2 + - - - \} \quad . . \quad (13)$$

then

$$Z = R_0 \xi^2 \{\chi_0 + \log(1/\alpha\kappa) - \kappa_1\} \quad . . \quad . . \quad (14)$$

This is the final impedance formula.

3. The Integration Constants

Equation (14) may be checked by solving equation (6) in powers of α, and extracting the coefficient κ_1, when the formula, previously found by Arnold[3] and others, using a relatively tedious method, is confirmed. To obtain a new and very simple formula, an asymptotic form of A_n must be found.

When ξ is very large, the function χ_n approximates to

$$\chi_n \approx \mathrm{I}_{n+1}(\xi)/\mathrm{I}_{n-1}(\xi) \quad . . \quad . . \quad . . \quad (15)$$

and is thus independent of k, provided

$$\exp\left[-2(1-k)|\xi|\right] \ll 1.$$

This simplified function (Butterworth's function[8]), can be seen to satisfy the equation

$$\left\{ \frac{d\chi_n}{d\xi} + \frac{\xi}{2n}(1+\chi_n)^2 + \frac{2n}{\xi}\chi_n \right\} = 0 \, (k=0) \quad . . (16)$$

which may be solved by successive approximations (starting with $\chi_n \approx 1$), to give*

$$\chi_n \sim \{1 - 2n.\xi^{-1} + n(2n-1).\xi^{-2} - \frac{1}{4} n(2n-1)(2n-3).\xi^{-3} + \frac{1}{4} n(2n-1)\,(2n-3).\xi^{-4} + - - - \} \quad . . \quad (17)$$

By substituting this into eqn. (6) and assuming that A_n possesses a similar form, it is found after considerable reduction that

$$A_n \sim \frac{[1-(1-4\alpha^2)^{\frac{1}{2}}]^n}{(2\alpha^2)^n} \Bigg\{ 1 - \frac{(1-\lambda)}{\lambda} n\xi^{-1} + \left[\frac{(1-\lambda)\,(1+\lambda-\lambda^2)}{2\lambda^3}.n + \frac{(1-\lambda)^2}{2\lambda^2} n^2 \right] \xi^{-2}$$

$$- \Bigg[\left(\frac{3\lambda^4(1-\lambda) + 2(2-5\lambda^2+3\lambda^4)}{8\lambda^5} \right) n + \left(\frac{(1-\lambda)^2}{4\lambda^4}(1-3\lambda^2) + \frac{3(1+\lambda)^2}{(3+\lambda^2)} \right) n^2 + \frac{(1-\lambda)^3}{2\lambda^3(3+\lambda^2)} n^3 \Bigg] \xi^{-3} + - - - \Bigg\} \quad . . \quad (18)$$

in which $\lambda \equiv (1-4\alpha^2)^{\frac{1}{2}}$. Thus

$$\kappa = \left[1-(1-4\alpha^2)^{\frac{1}{2}}\right]/2\alpha^2$$

and

$$\kappa_1 \sim \left\{ \frac{-(1-\lambda)}{\lambda\xi} + \frac{(1-\lambda)(1+\lambda-\lambda^2)}{2\lambda^3\xi^2} - \frac{[3\lambda^4(1-\lambda) + 2(2-5\lambda^2+3\lambda^4)]}{8\lambda^5\xi^3} + - - - \right\}$$

4. The New Formula

If $\beta = (1-4\alpha^2)^{-\frac{1}{2}}$, it follows from Equ. (14) that

$$Z \sim R_0\{\xi^2 \log(1/\alpha\kappa) + \beta.\xi + \beta(1-\tfrac{1}{2}\beta^2) + \frac{\beta}{8\xi}(9-10\beta^2+4\beta^4) + - - - \} \quad . . (19)$$

where $R_0 = 1/\pi\sigma a^2$, is the d.c. resistance of solid conductors of radius a. Extracting the real and imaginary parts gives

$$R'/R \sim (1-k^2) \left\{ \frac{\beta|\xi|}{2\sqrt{2}} + \frac{\beta(2-\beta^2)}{4} + \frac{\beta(9-10\beta^2+4\beta^4)}{16\sqrt{2}|\xi|} + - - - \right\} \quad . . (20)$$

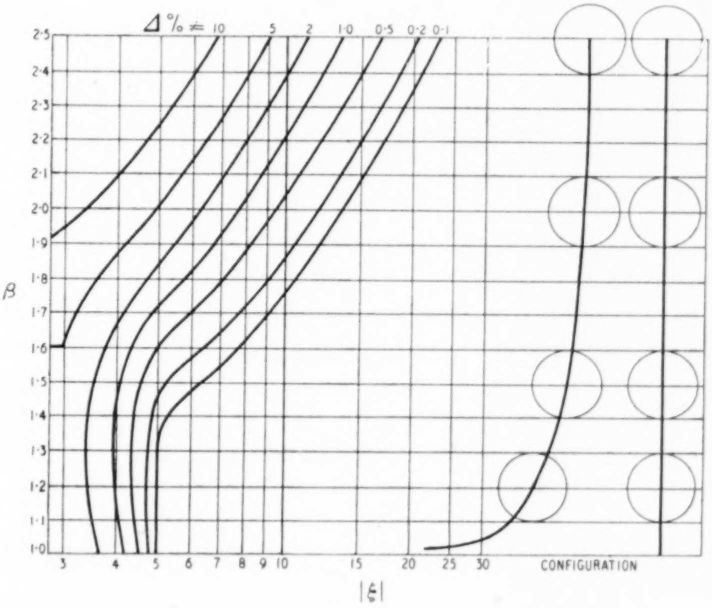
where R is the d.c. resistance of the hollow conductors, and k is the ratio of inner to outer radii; and

$$L' \sim \frac{\mu}{\pi} \left\{ \tfrac{1}{2} \log\left(\frac{\beta+1}{\beta-1}\right) + \frac{\beta}{\sqrt{2}|\xi|} - \frac{\beta(9-10\beta^2+4\beta^4)}{9\sqrt{2}|\xi|^3} + - - - \right\} \quad . . (21)$$

---

* The sign $\sim$ is used here in its conventional sense of 'Asymptotically equal to', which means that the formula is not accurate, but becomes more accurate as ξ becomes larger. The error is less than the last term included, and summation should be terminated at the smallest term.

Note that $|\xi| = (\mu\sigma\omega a)^{\frac{1}{2}} = (\mu\omega/\pi R_0)^{\frac{1}{2}}$; $\mu = 4\pi \times 10^{-7}$ for free space if L' is measured in henrys per metre.



5. Validity

The resistance formula can be compared numerically with Arnold's formula, and in this way the corresponding values of β and $|\xi|$ determined for a given error Δ. Fig. 2 gives a set of iso-error curves for Equ. (20) for values of β up to 2·5. The corresponding conductor spacings are illustrated and it can be seen that β is not likely to exceed this limit in practice.

Fig. 2 gives the error in the case of a solid conductor, and when hollow wires are used, a further condition is necessary:

$$|\xi| \geqslant \delta/(1-k) \qquad \ldots \quad \ldots \quad \ldots \quad (22)$$

where δ is plotted against Δ in Fig. 3.

In general it is found that the formula (20) is useful when the skin effect is sufficiently serious for R'/R to exceed 2. When $|\xi| > 3$ the accuracy of the formula can be improved to a large extent by estimating the error Δ from Fig. 2 and noting that the formula is always pessimistic in this range.

The error in the inductance formula will be less serious since L' does not vary over an infinite range with frequency. A comparison with Arnold's inductance formula[9] reveals analytical disagreement but a little experiment suggests that Arnold's error will not exceed 2·7%, and becomes negligible at low frequencies and when $\beta < 2$. By comparing equations (20) and (21) it can be seen that the percentage error in the quantity

$$\left\{\frac{\pi L'}{\mu} - \tfrac{1}{2}\log\left(\frac{\beta+1}{\beta-1}\right)\right\}$$

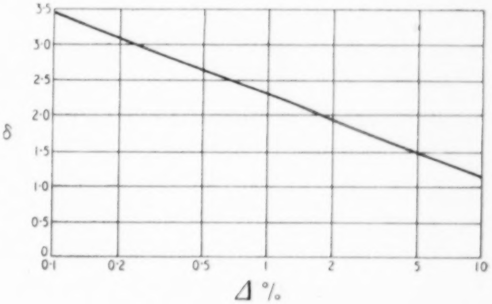
is of the order of $|\xi|$ times the error in R' for the same β and $|\xi|$.

6. Acknowledgments

This work has been accelerated by illuminating discussions with Mr. L. Lewin, and the author is grateful for permission from Standard Telecommunication Laboratories, Ltd., to present it.

Fig. 2 (left). *Iso-error curves for equation (20) for a solid conductor.*

Fig. 3 (below). *Values of δ to be used in equation (22) for a hollow conductor.*



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CORRESPONDENCE

Letters to the Editor on technical subjects are always welcome. In publishing such communications the Editors do not necessarily endorse any technical or general statements which they may contain.

Precision Voltage Source

SIR,—In a letter to *Wireless Engineer*,[1] Prof. Cunningham has discussed two points concerning errors in the non-linear bridge voltage-source.[2] Both here[1] and elsewhere[3] Prof. Cunningham mentioned that such errors were small although he gave no experimental values. However, the subject has recently been re-opened[4] without mention of the smallness of the errors involved, and the following notes may help to put the matter in the correct perspective.

The first point deals with components in the output additional to the well-known quadrature- and third-harmonic terms. These components result in a slight change in the relative amplitudes of the two terms. However, at 50 c/s the amplitude of the terms themselves amounts to only 1% of the fundamental output (i.e., 0·10% error in its r.m.s. value) so that the effect of the additional components is negligible.

The second, and much more important, point is the possibility of error due to the r.m.s. value of the bridge output being different on a.c. and d.c.: this was checked as follows. The r.m.s. value of the bridge output on a.c. and d.c. was compared to 1 part in 2,000 on a vacuo-junction and potentiometer. The input was adjusted to the same value on a.c. and on d.c. by the visual lamp-comparator[2] and, in another test, by an independent thermo-junction. At 50 c/s no difference in output between a.c. and d.c. could be detected, irrespective of the method used to set the input. The effective time-constant of the lamp was then reduced by increasing one resistance in the bridge, so that balance was obtained with the lamp running at its full rated voltage (6·3 V) instead of at half voltage. The error still could not be detected. Finally the frequency was reduced and a definite error of 0·1% was found at 20 c/s. These results may be compared with those just published by Prof. Cunningham.[5] Here a 115-V 3-W lamp is used in a 60-c/s lamp-bridge differential-voltmeter. When the lamp was run at half its rated voltage the error in the a.c./d.c. transfer was 0·1%; at full voltage the error was 0·3%. Clearly this error could be much reduced by using a lamp with more favourable characteristics.

From the foregoing it is evident that, in the case of the 50-c/s precision voltage-source, the errors considered by Prof. Cunningham are negligible and the performance may be taken as being exactly as given in the original article.[2]

V. H. ATTREE.

Fluid Motion Laboratory,
University of Manchester.
22nd June 1953.

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NATIONAL RADIO EXHIBITION

The 20th National Radio Show will be held at Earls Court, London, from 2nd to 12th September inclusive (except Sunday) from 11 a.m. until 10 p.m. The price of admission will be 2s. 6d. (1s. for those under 16 years old).

TECHNICAL LITERATURE

Lewis's Medical, Scientific and Technical Lending Library Catalogue; Supplement 1950-52 (inclusive)

Pp. 288. H. K. Lewis & Co., Ltd., 136 Gower Street, London, W.C.1. Price 6s. (to Library Subscribers 3s.).

R.C.A. Technical Papers (1952) Index Vol. III(b).

Pp. 15 + v. *R.C.A. Review*, Radio Corporation of America, R.C.A. Laboratories Division, Princeton, New Jersey, U.S.A.

An index to papers published in English by authors associated with R.C.A. It supplements Vol. I (1919–1945), Vol. II (1946–1950) and Vol. III(a) (1951).

Permanent Magnets

Pp. 59 + transparent chart in pocket. Permanent Magnet Association, 301 Glossop Road, Sheffield 10. Price 10s.

STANDARD-FREQUENCY TRANSMISSIONS

(Communication from the National Physical Laboratory)

Values for June 1953

Date 1953 June	Frequency deviation from nominal: parts in 10^8		Lead of MSF impulses on GBR 1000 G.M.T. time signal in milliseconds
	MSF 60 kc/s 1429-1530 G.M.T.	Droitwich 200 kc/s 1030 G.M.T.	
1	− 1·3	+ 3	+ 44·1
2	N.M.	+ 2	N.M.
3	− 1·4	+ 4	+ 37·8
4	− 1·4	+ 3	+ 36·2
5	− 1·4	+ 4	+ 33·1
6	− 1·5	+ 2	N.M.
7	− 1·4	+ 3	+ 28·2
8	− 1·4	+ 2	+ 25·5
9	− 1·3	+ 4	+ 23·2
10	− 1·3	+ 4	+ 20·5
11	− 1·3	+ 2	+ 18·8
12	− 1·4	+ 2	+ 16·9
13	− 1·4	+ 2	N.M.
14	− 1·3	+ 2	N.M.
15	− 1·3	+ 2	+ 10·9
16	− 1·3	+ 3	+ 9·2
17	− 1·3	+ 3	+ 7·1
18	− 1·3	+ 3	+ 4·6
19	N.M.	+ 4	N.M.
20	− 1·2	+ 3	N.M.
21	− 1·2	+ 3	N.M.
22	− 1·2	+ 3	− 5·8
23	− 1·2	+ 4	− 7·7
24	− 1·1	+ 3	− 10·9
25	− 1·1	+ 3	− 13·2
26	− 1·1	+ 2	N.M.
27	− 1·1	+ 2	N.M.
28	− 1·1	+ 2	N.M.
29	− 1·1	+ 3	− 20·3
30	− 1·0	+ 2	− 25·9

The values are based on astronomical data available on 1st July 1953.

The transmitter employed for the 60-kc/s signal is sometimes required for another service.

N.M. — Not Measured.

ABSTRACTS and REFERENCES

Compiled by the Radio Research Organization of the Department of Scientific and Industrial Research and published by arrangement with that Department.

The abstracts are classified in accordance with the Universal Decimal Classification. They are arranged within broad subject sections in the order of the U.D.C. numbers, except that notices of book reviews are placed at the ends of the sections. U.D.C. numbers marked with a dagger (†) must be regarded as provisional. The abbreviations of journal titles conform generally with the style of the World List of Scientific Periodicals. An Author and Subject Index to the abstracts is published annually; it includes a list of journals abstracted, the abbreviations of their titles and their publishers' addresses.

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ACOUSTICS AND AUDIO FREQUENCIES

534.213.4 **2193**

Theoretical Study of Vibratory Movements associated with Obstacles and Discontinuities.—J. Guittard. (*Acustica*, 1953, Vol. 3, No. 1, pp. 22–32. In French.) Experimental results obtained with brass tubes excited by sound waves, using powder-pattern or manometric-capsule methods of observation, are analysed mathematically.

534.231-13 **2194**

Second-Order Acoustic Fields: Relations between Energy and Intensity.—J. J. Markham. (*Phys. Rev.*, 1st March 1953, Vol. 89, No. 5, pp. 972–977.) Explicit calculations, based on Airy's general solution for the propagation of an elastic disturbance in a one-dimensional gas, are made of the average energy density and the average intensity of an acoustic wave. The front of the wave is shown to be a region of high density; it is followed by a region of lower density. This density variation seems to be a basic feature of a travelling wave in a gas and does not depend on the amplitude. See also 2964 of 1952.

534.321.9 : 534.61 **2195**

Sonde Method of Measuring the Ultrasonic Field Intensity.—S. Morita. (*J. phys. Soc. Japan*, March/April 1952, Vol. 7, No. 2, pp. 214–219.) The probes used were spheres of sound-absorbing materials of diameter about 2 mm, containing thermistors of diameter 0·3–0·5 mm. From the experimental results together with theoretical considerations it is concluded that generation of heat takes place at the surface of any solid in an ultrasonic field, and that the wave has a cooling effect. The measurements were made mainly at a frequency of 450 kc/s.

534.321.9-14 : 534.6 **2196**

Measurements of Sound Absorption in Water and in Aqueous Solutions of Electrolytes.—G. Kurtze & K. Tamm. (*Acustica*, 1953, Vol. 3, No. 1, pp. 33–48.) Four different techniques are described for measuring the absorption over different parts of the frequency range 4 kc/s–100 Mc/s. The results are discussed in relation to theories about the properties of the liquids.

534.845.1 **2197**

Measurement of Sound-Absorption Coefficients.—T. Vogel. (*Ann. Télécommun.*, March 1953, Vol. 8, No. 3, pp. 93–96.) Various difficulties encountered in the measurement of room reverberation times and of absorption coefficients are briefly discussed. A simple method for absorption measurement is described in which observations are made of the stationary-wave system produced near the face of a large sample of the material under test by interaction of the reflected waves with incident plane waves, the measurements being made in a large echo-free room. Experimental results at 575 c/s are compared with theoretical values derived on the basis of Rayleigh's theory.

534.846 **2198**

The Acoustics of the Royal Festival Hall, London.—P. H. Parkin, W. A. Allen, H. J. Purkis & W. E. Scholes. (*Acustica*, 1953, Vol. 3, No. 1, pp. 1–21.) Continuation of investigations previously noted [567 of 1952 (Parkin)]. Comments made by listeners indicate that the 'definition' is excellent, but that more 'fullness of tone' is desirable for some types of music. Reverberation time is considered to be the only practical objective criterion; the value of the reverberation time for this hall when full is 1·5 sec (at 500 c/s), i.e. 0·2 sec less than the optimum value given by Knudsen & Harris for a hall of this size. The 'fullness' would probably be adequate if the reverberation time could be increased to 1·7 sec or somewhat more.

621.395.612.451 **2199**

The Uniaxial Microphone.—H. F. Olson, J. Preston & J. C. Bleazey. (*RCA Rev.*, March 1953, Vol. 14, No. 1, pp. 47–63.) Modifications have been made to the ribbon microphone previously described [2697 of 1950 (Olson & Preston)] to produce a microphone which is directional and blastproof. The latter object is achieved by associating baffles with the ribbon so as to attenuate the low frequencies. Theoretical and measured directional patterns are given and frequency response characteristics are shown.

621.395.616 : 621.317.39 **2200**

Measurement of the Mechanical Tension of Capacitor-Microphone Diaphragms.—F. J. van Leeuwen. (*Electronica*, 11th April 1953, Vol. 6, No. 120, pp. 57–59.) Apparatus for measuring the diaphragm tension on the completely assembled microphone is described; its operation is based on the increase of capacitance resulting from application of a direct biasing voltage. Measurement results indicate that dural and nickel-foil diaphragms are relatively satisfactory as regards maintenance of tension.

621.395.623.7 **2201**

Loudspeaker Baffles and Cabinets.—J. A. Youngmark. (*J. Brit. Instn Radio Engrs*, Feb. 1953, Vol. 13, No. 2, pp. 89–98.) Graphs of the frequency response of loudspeakers mounted in baffles of various shapes and sizes and in open-back and bass-reflex cabinets are shown and discussed. Main attention is given to bass-reflex cabinets and the triangular corner type which, used with a low-impedance source, has certain advantages over the flat 'infinite' baffle. The general effect of a baffle on h.f. response is discussed and other design difficulties are briefly mentioned.

621.395.623.7.001.4 **2202**

Loudspeakers: Relations between Subjective and Objective Tests.—F. H. Brittain. (*J. Brit. Instn Radio Engrs*, Feb. 1953, Vol. 13, No. 2, pp. 105–109.) Objective testing unrelated to subjective experience is largely useless and can be very misleading, but objective tests made in an echo-free room can be satisfactorily correlated with subjective tests made in an ordinary living room. Hence pitch/loudness relations can be derived from frequency/intensity curves. Where a number of attributes are to be tested simultaneously, the subjective form of test is the only one possible.

621.395.625.3 **2203**

Notes on Wear of Magnetic Heads.—G. A. del Valle & L. W. Ferber. (*J. Soc. Mot. Pict. Telev. Engrs*, April 1953, Vol. 60, No. 4, Part II, pp. 501–504. Discussion, pp. 505–506.) Wear due to the physical contact between the magnetic-head pole pieces and the magnetic coating on striped motion-picture film is discussed. Measurement methods and results obtained on R.C.A. record/reproduce heads are described.

621.395.625.3 : 771.53 **2204**

Manufacture of Magnetic Recording Materials.—E. Schmidt & E. W. Franck. (*J. Soc. Mot. Pict. Telev. Engrs*, April 1953, Vol. 60, No. 4, Part II, pp. 453–462.) An account is given of techniques used in manufacturing the coating and base materials, and in applying the coating. Problems involved in the production of film with a stripe of magnetic material are discussed.

621.395.625.3 : 771.53 **2205**

Commercial Experiences with Magna-Stripe.—E. Schmidt. (*J. Soc. Mot. Pict. Telev. Engrs*, April 1953, Vol. 60, No. 4, Part II, pp. 463–467. Discussion, pp. 468–469.) Problems involved in providing photographic film with a stripe of magnetic material are discussed. Proposed standards for locating the stripe are based on data obtained from processing more than 2 000 prints, of various types, with a 'half' stripe (i.e. a stripe 0·050 in. wide, covering half the original photographic sound track).

621.395.625.3 : 771.53 **2206**

Magnetic Striping Techniques and Characteristics.—B. L. Kaspin, A. Roberts, Jr, H. Robbins & R. L. Powers. (*J. Soc. Mot. Pict. Telev. Engrs*, April 1953, Vol. 60, No. 4, Part II, pp. 470–482. Discussion, pp. 483–484.)

621.395.625.3 : 771.53 **2207**

Magnetic Striping of Photographic Film by the Laminating Process.—A. H. Persoon. (*J. Soc. Mot. Pict. Telev. Engrs*, April 1953, Vol. 60, No. 4, Part II, pp. 485–488. Discussion, pp. 489–490.)

621.395.625.3 : 771.53 **2208**

Magnetic Sound Tracks for Processed 16-mm Motion Picture Film.—T. R. Dedell. (*J. Soc. Mot. Pict. Telev. Engrs*, April 1953, Vol. 60, No. 4, Part II, pp. 491–499. Discussion, pp. 499–500.)

621.395.625.6 : 537.228.3 **2209**

Sound-on-Film Recording using Electro-optic Crystal Techniques.—R. Dressler & A. A. Chesnes. (*J. Soc. Mot. Pict. Telev. Engrs*, March 1953, Vol. 60, No. 3, pp. 205–216. Discussion, p. 216.) A modulator is described whose operation is based on the optical retardation produced by a crystal subjected to an electric field. ADP and KDP crystals are suitable. The electric field is applied parallel to the light beam, using transparent electrodes. 75% modulation is obtained with a total system distortion of about 3·3%; the required driving voltage of 2 kV r.m.s. is derived from a standard audio amplifier through a matching transformer.

AERIALS AND TRANSMISSION LINES

621.315.212 **2210**

Developments in High-Frequency Transmitter Cables.—R. C. Mildner. (*J. Brit. Instn Radio Engrs*, Feb. 1953, Vol. 13, No. 2, pp. 113–121.) Description of the mechanical and electrical characteristics of two types of coaxial cable with solid-wire inner conductor, for feeding the aerials of medium- and high-power transmitters. One has Al sheathing, the second is sheathed with Cu tape. Details of the range of accessories available are also given. The cables can be used for wavelengths down to the decimetre range.

621.392 : 621.396.67 **2211**

Losses in Aerial Feeders.—F. Moyano Reina. (*Rev. Telecomunicación, Madrid*, March 1953, Vol. 9, No. 31, pp. 10–13.) A formula for the radiation resistance of two-wire transmission lines is developed; this is used to find the power loss due to radiation. A calculation is made for a two-wire 200-m aerial feeder with steatite separators; radiation losses are much less than other losses at 1 Mc/s, and the total losses are less than for a good-quality coaxial cable with polystyrene insulation. Other advantages of the multi-wire line are its low cost and the ease with which it can be tested for standing waves.

621.392.21.029.64 **2212**

Microstrip—A New Transmission Technique for the Kilomegacycle Range.—D. D. Grieg & H. F. Engelmann. (*Elect. Commun.*, March 1953, Vol. 30, No. 1, pp. 26–35.) Reprint. See 621 of March.

621.392.21.029.64 **2213**

Simplified Theory of Microstrip Transmission Systems.—F. Assadourian & E. Rimai. (*Elect. Commun.*, March 1953, Vol. 30, No. 1, pp. 36–45.) Reprint. See 622 of March.

621.392.21.029.64 : 621.317.3 **2214**

Microstrip Components.—J. A. Kostriza. (*Elect. Commun.*, March 1953, Vol. 30, No. 1, pp. 46–54.) Reprint. See 623 of March.

621.392.26 **2215**

A Compact Broad-Band Microwave Quarter-Wave

Plate.—A. J. Simmons. (*Proc. Inst. Radio Engrs*, May 1953, Vol. 41, No. 5, p. 637.) Correction to paper abstracted in 3348 of 1952.

621.392.26 **2216**

On the Transient Phenomena in the Waveguide.—M. Namiki & K. Horiuchi. (*J. phys. Soc. Japan*, March/April 1952, Vol. 7, No. 2, pp. 190–193. Correction, *ibid.*, Nov./Dec. 1952, Vol. 7, No. 6, p. 652.) A theoretical investigation is made of wave distortion due to the variation of the phase velocity with frequency. The general formula is applied to examine the case when a sinusoidal oscillation is impressed at time $t = 0$; initial oscillations of appreciable amplitude precede the signal front. Long-distance transmission could be affected by these transient phenomena.

621.392.26 **2217**

Uniform Designation of Waves in Waveguides.—H. Meinke. (*Fernmeldetech. Z.*, March 1953, Vol. 6, No. 3, pp. 101–103.) The German Waveguide Standards issued in 1944 are discussed in relation to present-day usage in various countries.

621.392.26 : 537.226 **2218**

Shielded-Dielectric-Rod Waveguides.—R. E. Beam & H. M. Wachowski. (*Trans. Amer. Inst. elect. Engrs*, 1951, Vol. 70, Part I, pp. 874–880.) A dielectric rod surrounded by air and by a metal cylinder is termed a 'shielded-dielectric-rod waveguide'. Sets of curves are given showing (*a*) the value of λ/λ_g for different ratios of cylinder and rod radii for the TM_{01}, TE_{01} and HE_{11} modes, (*b*) the relative field distributions within the cylinder for the same three modes.

621.392.5 **2219**

Transmission-Line Load Impedance for Maximum Efficiency.—S. G. Lutz. (*Trans. Amer. Inst. elect. Engrs*, 1951, Vol. 70, Part I, pp. 283–285.) Full paper. See 2106 of 1951.

621.396.67 **2220**

Theory of Straight Aerials.—R. Gans & M. Bemporad. (*Arch. elekt. Übertragung*, April 1953, Vol. 7, No. 4, pp. 169–180.) Free oscillations of the aerial are discussed briefly, and conditions for reception and transmission are analysed in detail. Hallén's theory is recapitulated, and a contradiction in his basic integral equation is cleared up. A new method is presented for solving the integral equation expressing the current distribution; this reduces the problem to the solution of a system of linear equations. The method enables any required degree of approximation to be attained, and gives the solution in a form which enables particular properties of the aerial, e.g. the absorption area, to be calculated easily.

621.396.67 **2221**

Ground-Reflection Phase-Error Characteristics of a Vertical Antenna.—H. Greenberg & D. R. Meierdiercks. (*Proc. nat. Electronics Conf., Chicago*, 1952, Vol. 8, pp. 668–677.) Expressions for the phase error and amplitude factor are derived for the signal received from a vertical aerial fed at the base, the transmission being over ground of any given conductivity. Curves are given for the phase error and amplitude factor for an aerial about 60 ft in height, (*a*) with base at ground level, (*b*) with base at a height of 100 ft, ground conductivities being taken as those of sea water, average earth and poorly conducting earth. Curves for the elevated aerial fitted with a counterpoise system of radius 500 ft show a marked decrease of phase error with increase in amplitude. The transmission frequency is 1·7 Mc/s in all cases considered.

621.396.67.029.63 **2222**

U.H.F. Mobile Antenna.—E. F. Harris. (*Electronics*, May 1953, Vol. 26, No. 5, pp. 181–183.) Descriptions are given, with radiation patterns, of various arrangements of centre-fed vertical arrays of stacked elements. Coaxial cable is used for the feeder and is bent to form the radiating elements and phasing sections of the lower half of the array, the inner conductor being similarly treated for the upper half. A $\lambda/4$ isolating sleeve suppresses radiation from the line below the lowest $\lambda/2$ section. The whole array is moulded into a fibreglass supporting tube carried by a tubular metal mast. Such aerial systems cover wide frequency bands and should prove useful in the 450–470-Mc/s band.

621.396.677 **2223**

Use of the Rhombic Aerial for Reception.—H. Bohnenstengel. (*Fernmeldetech. Z.*, April 1953, Vol. 6, No. 4, pp. 172–178.) An investigation is made of the possibility of designing the rhombic aerial to pick up radiation polarized either in its own plane or in a perpendicular plane. To obtain uniform characteristic impedance a multiwire construction is desirable; details are given of the vertical spread required for a three-wire model. The requirements for the termination are studied by considering the aerial as a modified twin conductor. To be reflection-free, the terminating impedance must be complex, with an inductive component. Methods of measurement are indicated; measurements of voltage rather than resistance are required.

621.396.677 **2224**

An Experimental Investigation of the Corner-Reflector Antenna.—E. F. Harris. (*Proc. Inst. Radio Engrs*, May 1953, Vol. 41, No. 5, pp. 645–651.) Radiation patterns are shown for a dipole symmetrically located between two reflecting sheets including an angle θ. Results are given for values of θ from 30° to 270° and for spacings of $0{\cdot}1\lambda$ to 3λ between the dipole and vertex.

621.396.677 **2225**

Optimum Patterns for Endfire Arrays.—R. H. Duhamel. (*Proc. Inst. Radio Engrs*, May 1953, Vol. 41, No. 5, pp. 652–659.) The methods of Dolph (2487 of 1946) and Riblet (2685 of 1947) for optimum design of the broadside array with an odd number of elements have been modified so that a common design procedure can be used. This procedure is extended to the endfire array with an odd number of elements. A comparison is made between the optimum design and other designs of endfire array.

621.396.677.012.12 **2226**

Analysis of Microwave-Antenna Side-Lobes.—N. I. Korman, E. B. Herman & J. R. Ford. (*RCA Rev.*, March 1953, Vol. 14, No. 1, p. 127.) Correction to paper noted in 41 of January.

621.396.677.029.53 **2227**

Design and Performance Figures of a Medium-Wave Directional Aerial System.—R. Becker. (*Elektrotech. Z., Edn A*, 1st March 1953, Vol. 74, No. 5, pp. 158–161.) Calculations are made of the heights, diameters and spacing of two vertical aerials for directional transmission on 506 m, and the components of the feeder system for obtaining the correct phase relation of the feed currents are determined. Good agreement was obtained between the observed and calculated radiation diagrams. See also 222 of January (Eich).

621.396.677.029.62 **2228**

Slotted-Cylinder Aerials with Horizontal Directivity.—H. Bosse. (*Fernmeldetech. Z.*, March 1953, Vol. 6, No. 3, pp. 123–127.) Theory is developed to show that with a double-slotted cylinder of diameter $>0{\cdot}2\lambda$ it is possible to obtain a horizontal diagram in which the forward radiation is much greater than the backward or the lateral radiation, without any null directions. For diameters $<0{\cdot}2\lambda$, similar results can be obtained by providing dipoles in conjunction with a single-slotted cylinder. The calculations are confirmed by measurements.

CIRCUITS AND CIRCUIT ELEMENTS

538.652 : [621.392.52 + 621.396.611 **2229**

Some Applications of Permanently Magnetized Ferrite Magnetostrictive Resonators.—W. van B. Roberts. (*RCA Rev.*, March 1953, Vol. 14, No. 1, pp. 3–16.) For frequencies up to about 1 Mc/s, magnetostrictive resonators using ferrites are very much cheaper than crystal resonators. Toroidal magnetostrictive elements are discussed; by applying the biasing and driving fields in different directions, different modes of vibration are obtained. A definition is given of the coefficient of coupling between driving coil and resonator, this coefficient affording an indication of the efficiency, and being measurable with a Q meter. Applications of such devices as frequency-control elements in oscillator circuits and as components in various filter circuits are described.

621.3.015.7 : 621.387.4 **2230**

A Method ensuring Stability and Equality of Channel Widths in a Pulse-Amplitude Analyser.—H. Guillon. (*J. Phys. Radium*, Feb. 1953, Vol. 14, No. 2, pp. 128–129.) The method is basically that of Wilkinson (1199 of 1950). Pulses of amplitudes between 5 and 50 V are accepted, and bandwidth stability for 10-hour working periods is within ±0·2%.

621.3.016.35 **2231**

The Generalized Transmission Matrix Stability Criterion.—P. M. Honnell. (*Trans. Amer. Inst. elect. Engrs*, 1951, Vol. 70, Part I, pp. 292–296. Discussion, pp. 296–298.) Full paper. See 334 of 1952.

621.3.016.35 : 621.396.615 **2232**

Generalization of the Nyquist-Diagram Method for Nonlinear Systems.—A. Blaquière. (*J. Phys. Radium*, Dec. 1952, Vol. 13, No. 12, pp. 636–644.) Methods previously explained (1625 of June) are generalized to cover the case of oscillations represented by a nonlinear differential equation of any order.

621.314.22.015.7 **2233**

The Design of a Peaking Transformer.—A. B. Thomas. (*Proc. Instn Radio Engrs, Aust.*, March 1953, Vol. 14, No. 3, pp. 55–57.) The basic principles of the peaking transformer are outlined and the design of a transformer to produce 30-V pulses, of duration about 500 µs, from a 100-V 50-c/s input is discussed.

621.314.235.015.7 **2234**

Helical-Winding Slow-Wave Structures in Exponential-Line Pulse Transformers.—J. Kukel & E. M. Williams. (*Proc. Inst. Radio Engrs*, May 1953, Vol. 41, No. 5, p. 669.) A description is given of an experimental pulse transformer with integral hydrogen-thyratron pulse generator, suitable for use at the high impedance levels required in pulsed operation of magnetrons. The transformer has an outer cylindrical shell, the inner conductor consisting of a helix of constant diameter whose pitch decreases gradually from the thyratron end. Overall length is 1·81 m, input impedance 290Ω and output impedance 1590Ω.

621.314.3† **2235**

Steady-State Analysis of Self-Saturating Magnetic Amplifiers based on Linear Approximations of the Magnetization Curve.—W. H. Esselman. (*Trans. Amer. Inst. elect. Engrs*, 1951, Vol. 70, Part I, pp. 451–459.) A method is described for predicting the output currents of self-saturating magnetic amplifiers.

621.314.3† **2236**

The Transient Response of Magnetic Amplifiers — Cases of Negligible Commutation.—L. A. Finzi, D. P. Chandler & D. C. Beaumariage. (*Trans. Amer. Inst. elect. Engrs*, 1951, Vol. 70, Part I, pp. 934–942. Discussion, p. 942.) Full paper. Summary noted in 926 of 1952.

621.314.3† : 621.318.435 **2237**

A Saturable-Core Reference Source for Use with Magnetic Amplifiers.—A. G. Milnes & T. V. Vernon. (*J. sci. Instrum.*, April 1953, Vol. 30, No. 4, pp. 135–138.)

621.314.7 : 621.392.5 **2238**

Terminology and Equations for Linear Active Four-Terminal Networks including Transistors.—L. J. Giacoletto. (*RCA Rev.*, March 1953, Vol. 14, No. 1, pp. 28–46.) A general system of terminology is developed for linear active quadripoles, both nodal and loop analysis being presented. Definitions are given of current, voltage and power amplification factors, and the transformation equations are derived. The results are applied to a number of transistor circuits, the appropriate formulae being tabulated. Numerical examples are worked out.

621.316.541 **2239**

A Printed-Circuit Multiconductor Plug.—W. D. Novak. (*Proc. nat. Electronics Conf., Chicago*, 1952, Vol. 8, pp. 489–494; *Tele-Tech*, Jan. 1953, Vol. 12, No. 1, pp. 64–66 . . 112.)

621.316.86 : 537.312.6 **2240**

Thermistor Production.—W. T. Gibson. (*P.O. elect. Engrs' J.*, April 1953, Vol. 46, Part 1, pp. 34–36.) Short illustrated account of the manufacture of bead-type and rod-type thermistors from powdered mixtures of the oxides of Ni, Mn and Cu.

621.318.572 **2241**

A New Type of Waveguide Rotary Switch.—D. G. Kiely. (*J. Brit. Instn Radio Engrs*, Feb. 1953, Vol. 13, No. 2, pp. 100–103.) A high-speed waveguide switch is described which will connect two receivers or transmitters alternately to one aerial and which is particularly suitable for centimetre wavelengths. The performance of a model operating at 8 mm λ was satisfactory.

621.318.572 **2242**

Scale-of-Ten Counting Unit using Four Double Triodes.—R. Wahl. (*J. Phys. Radium*, Dec. 1952, Vol. 13, No. 12, pp. 670–671.) Description of a scale-of-16 circuit converted to scale-of-ten operation by means of feedback from the fourth to the second stage, Ge crystals being used for the feedback coupling and for that between the first and second stage.

621.318.572 : 621.314.7 **2243**

A Transistor Reversible Binary Counter.—R. L. Trent. (*Proc. nat. Electronics Conf., Chicago*, 1952, Vol. 8, pp. 346–357.) See 650 of March.

621.319.4.029.5 **2244**

The Properties of Capacitors at High Frequencies.—W. Hartmann. (*Bull. schweiz. elektrotech. Ver.*, 21st March 1953, Vol. 44, No. 6, pp. 258–262. In German.) The variations with frequency of the capacitance and loss angle of capacitors are deduced from the equivalent circuit, the frequencies considered ranging up to the television band. The self-resonance frequencies of paper, mica and ceramic capacitors, taking account of wire leads, are shown by curves. Other curves show the variation of loss angle with frequency.

621.392 **2245**

On Linear Electrical Networks.—B. Gross. (*Ann. Acad. bras. Sci.*, 31st Dec. 1952, Vol. 24, No. 4, pp. 443–447.) Preliminary note of a method of analysis in terms of network admittance.

621.392.015.3 **2246**

The Calculation of Carrier-Frequency Transients.—W. Händler & J. Peters. (*Fernmeldetech. Z.*, April 1953, Vol. 6, No. 4, pp. 179–188.) By using function theory and the Laplace-transform method, exact calculations are made without introducing any assumptions regarding the phase response of the transmission system. Demodulation calculations by two methods are considered. As an example of use of the preferred method, a calculation of the carrier-frequency transients is made for the vestigial-sideband i.f. amplifier described by Zimmermann (2062 of 1952); a step voltage is used for modulation. In appendices, the practical application of the residue theorem to transmission calculations is demonstrated, and a chart for plotting transients is presented.

621.392.4/.5 **2247**

Equivalent Circuits using Negative Two-Pole Elements.—W. Klein. (*Arch. elekt. Übertragung*, April 1953, Vol. 7, No. 4, pp. 198–201.) Calculations for three-pole and multipole networks are simplified by substitution of equivalent circuits consisting only of two-pole elements, some of which have negative values.

621.392.4.012 **2248**

Loci of Complex Impedance and Admittance Functions.—E. L. Michaels. (*Trans. Amer. Inst. elect. Engrs*, 1951, Vol. 70, Part I, pp. 299–303.) Full paper. See 2125 of 1951.

621.392.43 **2249**

Impedance Matching with Transformer Sections.—R. W. Klopfenstein. (*RCA Rev.*, March 1953, Vol. 14, No. 1, pp. 64–71.) An equivalent circuit for a transmission-line transformer section is discussed which allows considerable flexibility in design and enables end effects to be easily taken into account.

621.392.5 **2250**

On the Approximation Problem in Network Synthesis.—A. D. Bresler. (*Proc. Inst. Radio Engrs*, May 1953, Vol. 41, No. 5, p. 644.) Correction to paper abstracted in 660 of March.

621.392.5 **2251**

Networks for which Magnitude or Phase Angle of Input Impedance or Transfer Admittance remains Constant as Load Varies.—R. S. Berkowitz. (*Trans. Amer. Inst. elect. Engrs*, 1951, Vol. 70, Part I, pp. 286–291.) The conditions are determined that must be satisfied by a network at constant frequency to obtain a particular variation of input impedance or transfer admittance when the load changes in a specified way. Results are tabulated for ten special cases.

621.392.5 **2252**

The Parameters of a Four-Terminal Network.—A. E. Ferguson. (*Aust. J. appl. Sci.*, March 1953, Vol. 4, No. 1, pp. 18–27.) The method of analysing quadripoles in terms of image impedances and a propagation constant is compared with the method based on the general circuit constants; the latter method, which can conveniently be treated by matrix algebra as described by Guertler (2440 of 1950), is preferred. The relation between the two sets of constants is examined and typical applications are illustrated.

621.392.5 **2253**

Note on the Iterated Network and its Application to Differentiators.—H. L. Armstrong. (*Proc. Inst. Radio Engrs*, May 1953, Vol. 41, No. 5, p. 667.) An alternative proof is given of the formula for a power of a matrix recently given by Pease (2457 of 1952).

621.392.5 **2254**

Use of Locus Diagrams to determine the Equalizing Action of Bridged-T Networks.—E. Thinius. (*Fernmeldetech. Z.*, March 1953, Vol. 6, No. 3, pp. 109–115.) Numerical examples are used to show the method of determining from the impedance diagram the variation with frequency of the attenuation and phase coefficients of bridged-T networks of different types.

621.392.5 **2255**

How to Design Notch Networks.—C. J. Savant, Jr. (*Electronics*, May 1953, Vol. 26, No. 5, pp. 188–191.) Curves are given which simplify the design of capacitor-shunt or resistor-shunt bridged-T networks and of parallel-T networks of the infinite-attenuation *RC* type.

621.392.5 **2256**

Synthesis of Unbalanced *RLC* Networks.—L. Weinberg. (*Proc. nat. Electronics Conf., Chicago*, 1952, Vol. 8, pp. 598–608; *J. appl. Phys.*, March 1953, Vol. 24, No. 3, pp. 300–306.) Each inductor of the network is assumed to have associated series resistance. The method of synthesis makes use of novel features, including (*a*) the breakdown of a Hurwitz polynomial into two others, (*b*) application of a network theorem to division of the network into two parts, and (*c*) a method of zero shifting with one pair of complex poles, (*a*) and (*c*) being discussed in appendices. The network realizes a minimum-phase transfer function whose numerator and denominator are of degree not higher than the third and fourth respectively, and whose poles and zeros may lie anywhere in the left half of the complex-frequency plane. Extension of the procedure to functions of higher degree is considered briefly.

621.392.5 **2257**

High-Characteristic-Impedance Distributed-Constant Delay Lines for Fractional-Microsecond Pulses.—W. S. Carley & E. F. Seymour. (*Proc. nat. Electronics Conf., Chicago*, 1952, Vol. 8, pp. 787–798.) The delay lines described are pile wound with wire of 41–48 gauge (about 1 500 turns/in.) on polystyrene rods previously coated with silver paint, slotted lengthwise at 10° intervals and then insulated with teflon tape prior to winding. A typical line, 10 in. in length and 0·2 in. in diameter, has a characteristic impedance of 5·6 kΩ, a delay of 3·7 μs and an attenuation of the order of 0·3 db/μs. Pulse rise and fall times are about 0·1 μs. Response curves for pulses of 0·3, 0·37, 0·6, 1·0 and 2·4 μs duration are given. Characteristics of 5·6-kΩ and 10-kΩ lines are tabulated. See also *Electronics*, April 1953, Vol. 26, No. 4, pp. 188–192, 194.

621.392.5 **2258**

Phase and Group Delay.—R. Krastel. (*Funk u. Ton*, Feb. 1953, Vol. 7, No. 2, pp. 74–83.) Expressions for phase and group delay are obtained and the design of low-pass delay networks is considered, with illustrative numerical examples.

621.392.5 : 621.396.645 **2259**

Networks with Maximally Flat Delay.—Kiyasu-

Zen'iti, Nobuiti Ikeno & Sigeharu Yamada. (*Wireless Engr*, June 1953, Vol. 30, No. 6, pp. 158–159.) Comment on 3375 of 1952 (Thomson).

621.392.52 **2260**

Wiener's Theory of Linear Filtering.—D. A. Bell. (*Wireless Engr*, June 1953, Vol. 30, No. 6, pp. 136–142.) Wiener's theory (2465 of 1950) introduces the concept of the 'optimum linear filter' for use when signal and noise occupy the same frequency band. This concept is examined without attempting to follow the complex mathematics of the original. The discussion is limited to the extreme cases of 'zero-lag' and 'infinite-lag' filters, which are appropriate respectively to telecommunication and automatic-control systems. A formula is derived for the transfer characteristic of the optimum filter for an input signal having the power spectrum $1/(1 + \omega^2)$ with uniform random noise. For the zero-lag case the transfer characteristic is affected by consideration of phase/frequency variations; for the infinite-lag case it is not. For applications in which delay can be tolerated, the infinite-lag filter has the advantage of transmitting a much greater fraction of the input power. The applicability of 'optimum' filters is discussed.

621.396.6 **2261**

Improved Components and Materials for Reliable Electronic Equipment.—A. W. Rogers & B. A. Diebold. (*Elect. Mfg*, Nov 1951, Vol. 48, No. 5, pp. 114–119 . . 280.) Discussion of improvements in components and manufacturing techniques resulting from a U.S. Signal Corps research programme.

621.396.6 : 061.4 **2262**

The National Radio-Components Exhibition, 1953.—J. Rousseau. (*TSF et TV*, April & May 1953, Vol. 29, Nos. 294 & 295, pp. 157–161 & 189–195.) Review of annual exhibition in Paris, with descriptions and illustrations of selected items. For other accounts see *Toute la Radio*, May 1953, Vol. 20, No. 175, pp. 157–168 and *Télévision*, May 1953, No. 33, pp. 113–118.

621.396.6 : 681.142 **2263**

Circuitry 'Packages' for Electronic Computers.—(*Tech. News Bull. nat. Bur. Stand.*, March 1953, Vol. 37, No. 3, pp. 36–37.) Short description of etched-circuit mass-produced units, $7 \times 3{\cdot}5 \times 1$ in., with projecting pin connections. The basic unit comprises a transformer-coupled pulse amplifier using a Type-6AN5 miniature beam-tetrode, and a number of Ge diodes. Four variants of the basic unit meet most computer-circuit requirements. A new computer including 800 such units is under construction. Test jacks facilitate location of defective units and of defective components of individual units.

621.396.611.1 **2264**

Electrical Oscillations: a Physical Approach to the Phenomena.—A. W. Gillies. (*Wireless Engr*, June 1953, Vol. 30, No. 6, pp. 143–158.) Phenomena occurring in oscillator circuits are explained in terms of modulation products. For an input signal of given form an analysis is made of the modulation products introduced by the curvature of the characteristic of a nonlinear resistor, the characteristic being represented to any required degree of accuracy by a polynomial. The operation of a negative-resistance oscillator including a nonlinear resistor is explained in terms of this analysis. In general the oscillation frequency deviates slightly downwards from the resonance frequency associated with the linear part of the circuit. Forced oscillations and synchronization are considered. A vector representation is developed for transient behaviour and combined oscillations. For detailed mathematical discussion see 308 of 1950.

621.396.611.1 **2265**

The Response of a Tuned Circuit to a Ramp Function.—M. S. Corrington. (*Proc. Inst. Radio Engrs*, May 1953, Vol. 41, No. 5, pp. 660–664.) A ramp function is defined as one whose value increases linearly up to a certain point and then remains constant. Response curves are shown for a parallel-tuned LRC circuit subjected to (*a*) a linearly increasing driving force, (*b*) ramp voltages with various rise times. In each case curves are given for circuit Q values of 0·5, 1, 2, 4, 8 and ∞.

621.396.611.1.012.1 : 512.942 **2266**

Three-Dimensional Locus Curves for Describing the Properties of Electrical Circuits.—D. M. Tombs. (*Elektrotech. Z.*, *Edn A*, 11th April 1953, Vol. 74, No. 8, pp. 232–234.) In the Jahnke-Emde 'Tafeln höherer Funktionen' (2826 of 1949) the Fresnel integral is shown by an isometric representation of a space curve. Prowse (2481 of 1948) has shown that the characteristics of an oscillatory circuit can be similarly represented by a three-dimensional locus curve whose projections on the three reference planes give respectively the usual circle diagram, a resonance curve, and an N-shaped susceptance diagram. Wire models, on similar lines, are described which show the relation between impedance and frequency, or between admittance and frequency, for some simple and coupled circuits.

621.396.611.21.029.45 **2267**

A New Quartz Oscillator for the Frequency Range 1–20 kc/s.—A. Karolus. (*Elektrotech. Z.*, *Edn A*, 1st March 1953, Vol. 74, No. 5, pp. 136–140.) A quartz oscillator in the form of a tuning fork is described. Each prong carries four electrodes arranged according to the cut of the crystal and connected so that on application of a voltage via the spring suspensions the inner and outer halves of each prong are stressed in opposite directions. In air the Q factor is 2×10^4, increasing to 10^5 at a pressure of a few mm Hg. With thermostatic control the frequency variation can be kept to within 1 part in 10^8.

621.396.611.4 **2268**

Electromagnetic Field Expansions in Loss-Free Cavities Excited through Holes.—T. Teichmann & E. P. Wigner. (*J. appl. Phys.*, March 1953, Vol. 24, No. 3, pp. 262–267.) "The electromagnetic field in a loss-free cavity excited through holes cannot be completely expressed in terms of the short-circuit modes of the cavity satisfying the condition that the tangential component of the electric field is zero on the boundary of the cavity including the openings. For a complete expansion it is necessary to add an irrotational magnetic field, which contributes a term inversely proportional to the frequency, to the usual admittance matrix. If the cavity is presumed to include a reasonable portion of the guides feeding the openings, this irrotational component becomes almost diagonal."

621.396.615.018.751 : 621.317.755 **2269**

The Sawtooth Derivator.—D. Admiraal. (*Electronic Applic. Bull.*, Aug./Sept. 1952, Vol. 13, Nos. 8/9, pp. 117–137.) The sawtooth derivator differs fundamentally from the conventional type of timebase generator in that the required waveform is derived from an arbitrary waveform which, in its turn, is derived from the signal applied to the c.r.o. In this way perfect synchronization is obtained. Various types of clipping and differentiating circuits are discussed and a description is given, with full circuit details, of practical equipment which functions entirely automatically and covers the frequency range 30 c/s–15 kc/s without any switching operations.

621.396.615.029.62 **2270**

220-Mc/s Oscillator with a TBW-6/6000 or TBL-6/6000 Transmitting Valve.—G. Mol. (*Electronic Applic.*

Bull., Aug./Sept. 1952, Vol. 13, Nos. 8/9, pp. 138–144.) Details are given of the construction of a self-excited oscillator using either a water-cooled or an air-cooled high-power transmitting valve. Illustrations are given of the special anode-grid and cathode-grid circuit arrangements and of the method of coupling used for a water-cooled dummy load consisting of a λ/4 shorted coaxial line. The power dissipated in the load, about 3·25 kW, is estimated from the rise in temperature and rate of flow of the cooling water.

621.396.615.14 : 621.385.3 **2271**

A Mode of Oscillation of Conventional Triode Valves.—G. Raoult & R. Turlier. (*C. R. Acad. Sci., Paris*, 9th March 1953, Vol. 236, No. 10, pp. 1007–1009.) Analysis shows that if certain conditions are satisfied u.h.f. oscillations are possible in a triode valve designed for lower frequencies. This was verified for a Telefunken Type-LS180 triode, which is designed to oscillate on wavelengths down to about 50 cm. The valve has two grid and two anode terminals and to these a resonant 4-wire system was attached, with a 20-kΩ resistor and milliammeter connected between grid and earth. With an anode voltage of 500 V good oscillations on a wavelength of 11·4 cm were obtained, the mean oscillatory voltage on the grid being about 30 V and on the anode about 300 V. The calculated wavelength was about 11 cm.

621.396.615.17 **2272**

Stability in Negative-Feedback Time-Bases.—A. B. Starks-Field. (*Electronic Engng*, May 1953, Vol. 25, No. 303, pp. 192–197.) The term 'double stroking' is applied to a condition in which alternate scanning strokes are dissimilar; this phenomenon is liable to occur during starting, and may continue indefinitely, in any timebase where the initiation of flyback depends on the conditions existing at the end of the scan and the flyback is maintained linear. The process is examined in detail for some typical circuits.

621.396.616 : 621.318.572 **2273**

Interesting Nonlinear Effects.—R. S. MacKay. (*J. appl. Phys.*, March 1953, Vol. 24, No. 3, pp. 311–313.) Experiments show that simple circuits comprising ordinary electric lamps together with iron-core transformer coils and capacitors have properties similar to some multivibrators and ring circuits. Applications to switching, counting and delaying are indicated.

621.396.645.015.7 : 621.387 **2274**

The Gas-Filled Triode as Pulse-Amplifier Valve.—E. Knoop. (*Z. angew. Phys.*, March 1953, Vol. 5, No. 3, pp. 105–107.) An experimental investigation is reported. Using a special circuit to avoid permanent ignition, a recovery time of 2 μs can be attained with a He-filled Type-EC50 valve. For applied pulses of duration > 1 μs the operating threshold value of input voltage may be as low as 0·1 V; for shorter pulses the threshold is a few volts. As pulse width and height decreases, the build-up time for the discharge increases, and the time delay of the amplified pulse is increased. The gas triode is thus only appropriate in the output stage of a pulse amplifier.

621.396.645.018.424 **2275**

Video Amplifiers with Extremely Large Bandwidth.—F. J. Tischer. (*Elektrotech. Z.*, *Edn A*, 1st March 1953, Vol. 74, No. 5, pp. 131–133.) Practical designs of a cascade amplifier and one with distributed amplification are illustrated. Comparison of the two types shows certain advantages of the cascade type.

621.396.645.35 **2276**

A Direct-Voltage Amplifier for Voltages down to 10^{-9} V [from sources] **having Low Internal Resistance.**—W. Kroebel. (*Naturwissenschaften*, March 1953, Vol. 40, No. 6, p. 197.) The low voltage threshold is achieved by using a crystal contact relay and Tesla transformer in the input circuit to convert the d.c. to a.c. for amplification.

621.396.645.35 **2277**

A Survey of the Limits in D.C. Amplification.—C. M. Verhagen. (*Proc. Inst. Radio Engrs*, May 1953, Vol. 41, No. 5, pp. 615–630.) The effect of a change of the cathode temperature of planar diodes and triodes is calculated and the possibility of compensating this temperature effect is discussed. The effect of anode-voltage changes is analysed and some new compensating circuits are described which enable dynamic and in-phase balance to be obtained simultaneously with a single adjustment. For all balanced circuits the requirements as regards stability of the supply or auxiliary voltage are found to be nearly the same. Changes of valve constants with time are discussed. Investigation showed that the poorly defined position of the heater in the cathode sleeve of some valves seriously limited their stability.

621.396.645.371.081.78 **2278**

Harmonic Distortion and Negative Feedback.—R. O. Rowlands. (*Wireless Engr*, June 1953, Vol. 30, No. 6, pp. 133–135.) An analysis is made which takes account of the production of harmonics of order higher than the second by the negative-feedback process. The usual formula for the reduction of distortion by application of negative feedback is accurate if the slope of the amplifier output-voltage/input-voltage curve does not vary appreciably over the working range. If a valve with a sharp cut-off is used and the input voltage is greater than the cut-off value, no reduction of distortion can be effected by negative feedback.

621.396.822 : 621.396.645 : 621.314.7 **2279**

Noise in Transistor Amplifiers.—E. Keonjian & J. S. Schaffner. (*Proc. nat. Electronics Conf., Chicago*, 1952, Vol. 8, pp. 343–345.) See 1288 of May.

621.392.52 **2280**

Filter Design Data for Communication Engineers. [Book Review]—J. H. Mole. Publishers: E. & F. N. Spon, 1952, 252 pp., 63s. (*Electronic Engng*, May 1953, Vol. 25, No. 303, p. 221.) A design procedure is outlined which permits rapid computation of the element values of the optimum Zobel filter having a given attenuation characteristic.

GENERAL PHYSICS

534.2 : 537.3 **2281**

The Acousto-Electric Effect.—R. H. Parmenter. (*Phys. Rev.*, 1st March 1953, Vol. 89, No. 5, pp. 990–998.) Theoretical calculations indicate that an electric current should be generated in a crystal by the passage through it of an acoustic wave. In a metal, the electrons concerned are at the Fermi level; in an *n*-type semiconductor they are in the conduction band. Calculations for Na and for *n*-type Ge indicate that the predicted effect should be measurable.

535.37 : 537.228 **2282**

Initial Rise of Brightness of Electroluminescent Substances under the Action of an Alternating Field.—F. Vigean. (*C. R. Acad. Sci., Paris*, 16th March 1953, Vol. 236, No. 11, pp. 1151–1153.) Observed phenomena can be explained on the assumption of excitation of luminescence centres by conduction-band electrons that have acquired sufficient energy. These electrons reach the conduction band from electron donor levels a few tenths of an electron-volt below, and are then accelerated.

535.37 : 537.228 **2283**

Influence of Electric Fields on Luminescence.—F. Matossi & S. Nudelman. (*Phys. Rev.*, 1st Feb. 1953, Vol. 89, No. 3, pp. 660–661.) Brief report of an investigation of the luminescence of a ZnS-Cu phosphor excited by near-ultraviolet radiation and subjected to alternating electric fields at frequencies up to 10 kc/s. The procedure used was similar to that of Destriau (110 of 1949).

535.37 : 537.228 **2284**

Effect of an Electric Field on a Continuously Excited Phosphor.—F. Matossi. (*Naturwissenschaften*, April 1953, Vol. 40, No. 8, pp. 239–240.) When an alternating electric field is applied to a ZnS-Cu phosphor excited to steady-state luminescence, a momentary increase of luminescence is observed, with a subsequent drop and a slow change to a new steady state, a periodic intensity ripple, of double the field frequency, being superposed. Switching off the field generally results in a new momentary intensity with subsequent gradual return to the initial value. These effects are explained on the basis of theory given by Randall & Wilkins (1808 of 1946).

537.213 + 538.123] : 517.947.42 **2285**

Vector Potential Derivation from Scalar Potentials.—J. J. Smith. (*Elect. Engng, N.Y.*, Sept. 1952, Vol. 71, No. 9, p. 802.) Digest of paper presented at A.I.E.E. District Meeting, May 1952. Definitions are given of vector potential; it is shown that vector potentials can be derived from the scalar potentials included in the Tables of Green's Functions (2360 below). Results are given for the field due to a thin rectangular sheet of magnetic material or a rectangular coil.

537.221 **2286**

Calculation of Contact Potentials.—H. Dormont. (*C. R. Acad. Sci., Paris*, 9th March 1953, Vol. 236, No. 10, pp. 1009–1011.) A formula is derived for the contact potential between two metals from consideration of Fermi energy levels and surface thermal-electron flux.

537.221 **2287**

Contact Phenomena.—H. Dormont. (*C. R. Acad. Sci., Paris*, 23rd March 1953, Vol. 236, No. 12, pp. 1238–1240.) Continuation of investigation noted in 2286 above. If the two barrier layers have the same transparency, the usual formula for contact potential is found in terms of the constants of the Dushman-Richardson equation; if the two barrier layers have different transparencies, a correction term comes into play. Analysis indicates that by making sufficiently accurate measurements of contact potential it should be possible to separate emission-constant variation due to variation of work function with temperature from that due to barrier transparency.

537.311.1 : 621.396.822 **2288**

Electrical Fluctuation Phenomena.—H. Witt. (*Z. Phys.*, 2nd Dec. 1952, Vol. 133, No. 5, pp. 661–664.) The possibility is discussed that fluctuation phenomena in insulating materials may have their origin in recombination fluctuations of the freed electrons with their positive residual charges, the recombination fluctuations being related to the statistical density fluctuations of the solid and being amplified by the mechanism of electronic conduction.

537.311.33 **2289**

Transistors: Theory and Applications: Part 3—Physical Properties of Electrons in Solids.—A. Coblenz & H. L. Owens. (*Electronics*, May 1953, Vol. 26, No. 5, pp. 162–165.) Presents a concept of the electron that fits with generally accepted explanations of phenomena in semiconductor materials that are responsible for transistor action. Part 2: 1957 of July.

537.523.093 **2290**

Dependence of Direct Sparkover Voltage of Gaps on Humidity and Time.—P. B. Jacob, Jr, & G. M. L. Sommerman. (*Trans. Amer. Inst. elect. Engrs*, 1951, Vol. 70, Part I, pp. 921–924. Discussion, pp. 924–925.) A systematic investigation of humidity and time effects on the breakdown voltage for gaps using (*a*) spheres 12·5 cm in diameter, (*b*) standard rods, ½ in. square section, with square edges. Results are shown graphically and discussed.

537.562 : 538.632 **2291**

General Expression for the Conductivity Tensor and for the Dielectric Tensor in an Ionized Medium. Various Applications: Hall Effect and Generalization of Langevin's Formula for Mobility.—T. Kahan & R. Jancel. (*C. R. Acad. Sci., Paris*, 13th April 1953, Vol. 236, No. 15, pp. 1478–1481.) A calculation to a first order of approximation is made of the distribution function for electrons in an ionized gas exposed to crossed magnetic and electric fields. The rate of diffusion of the electrons is deduced and expressions are derived for the conductivity and dielectric tensors. In a later paper the formulae obtained are to be discussed and compared with those established by Huxley (1266 of 1952).

538 : 061.3 **2292**

Washington Conference on Magnetism, 2nd–6th September 1952.—(*Rev. mod. Phys.*, Jan. 1953, Vol.25, No. 1, 351 pp.) The 66 papers presented at the conference are given in full, with reports of the discussions.

538.12 **2293**

The External Magnetic Field of a Single Thick Semi-Infinite Parallel Plate terminated by a Convex Semicircular Cylinder.—N. Davy & N. H. Langton. (*Quart. J. Mech. appl. Math.*, March 1953, Vol. 6, Part 1, pp. 115–121.)

538.3 **2294**

General Solutions of Maxwell's Equations.—É. Durand. (*C. R. Acad. Sci., Paris*, 8th April 1953, Vol. 236, No. 14, pp. 1407–1409.) Expressions are derived which are sufficiently general to cover the case of charges or currents within the volume considered.

538.56 : 535.42 **2295**

Diffraction by a Thick Semi-infinite Plate.—D. S. Jones. (*Proc. roy. Soc. A*, 8th April 1953, Vol. 217, No. 1129, pp. 153–175.) A method of analysis based on that previously described (374 of February) is applied to the problem of the diffraction of a two-dimensional plane harmonic wave by a semi-infinite perfectly conducting plate of thickness *d*. Expressions are obtained for the distant field when *d* has any value, and the effects at the boundary of the shadow are deduced. Extension of the theory to the problem of diffraction by a thick plate of finite length is briefly discussed. The theory is also extended to incident scalar waves whose direction of propagation does not lie in the plane perpendicular to the plate.

538.56 : 535.42 **2296**

The Diffraction of a Dipole Field by a Perfectly Conducting Half-Plane.—T. B. A. Senior. (*Quart. J. Mech. appl. Math.*, March 1953, Vol. 6, Part 1, pp. 101–114.) A method of analysis is developed which is valid for any orientation of the dipole; the dipole field is resolved into plane waves whose diffraction can be studied independently. The particular case of an electric dipole with its axis normal to the half-plane is investigated.

538.566 : 537.56 **2297**

Absorption in an Electron-Gas Mixture.—H. Kober. (*Ann. Phys., Lpz.*, 10th Oct. 1952, Vol. 11, No. 1, pp.

1–11.) The influence of the collision damping on the polarization of an electron-gas mixture subjected to an alternating electric field is calculated using the kinetic theory of gases and assuming the simplest type of elastic collision. The nonlinear effect of the absorption is estimated to a first approximation; this nonlinearity is significant for long waves propagated in the ionosphere.

538.569.4 **2298**

Microwave Absorption Spectrum of ND$_3$.—R. G. Nuckolls, L. J. Rueger & H. Lyons. (*Phys. Rev.*, 1st March 1953, Vol. 89, No. 5, p. 1101.) The frequencies of the main *J, K* sequence of inversion lines in the ND$_3$ absorption spectrum between 1·589 and 2·54 kMc/s, measured in a coaxial type of Stark cell, are tabulated together with values calculated from an NH$_3$-type formula.

538.613 **2299**

The Faraday Effect in Conductors and Semiconductors.—A. Surduts. (*C. R. Acad. Sci., Paris*, 9th March 1953, Vol. 236, No. 10, pp. 1005–1007.) Analysis on classical lines is presented for the effect on a plane-polarized plane e.m. wave of an applied constant magnetic field in the direction of propagation. A formula for the rotation of the plane of polarization is derived which may possibly be checked experimentally.

538.691 : 537.122 **2300**

The Influence of Magnetic Impulses on the Kinetic Energy of Electrons.—L. Kolodziejczyk. (*C. R. Acad. Sci., Paris*, 13th April 1953, Vol. 236, No. 15, pp. 1476–1478.) Analysis is presented showing that magnetic impulses, such as those caused by e.m. waves with discontinuities in the magnetic components, may produce variation of the kinetic energy of electrons and may contribute to the destruction of atomic structures.

539.211 : 537.533 **2301**

Surface Investigation of Metals and Nonmetals with Exo- and Photoelectrons.—J. Kramer. (*Z. Phys.*, 2nd Dec. 1952, Vol. 133, No. 5, pp. 629–646.) The term 'exo-electrons' is applied to electrons emitted from a surface under excitation by light of sufficiently short wavelength, an exothermic process being involved. A description is given of the special Geiger-type needle counter used in the investigation, the light source with plexiglas lenses being built into the counter. Results obtained are shown graphically and discussed; they include curves showing (*a*) the decay of exo- and photoelectron emission from emery-treated Pt, stretched Al, and gypsum, and (*b*) temperature variation of exoelectron emission from gypsum, CaO, quartz and quinine sulphate subjected to various types of irradiation.

621.3.011.4 : 518.12 **2302**

Calculation of the Capacitance of a Circular Annulus by the Method of Subareas.—T. J. Higgins & D. K. Reitan. (*Trans. Amer. Inst. elect. Engrs*, 1951, Vol. 70, Part I, pp. 926–931. Discussion, pp. 931–933.) An approximation method is described and applied to the determination of the capacitance and charge distribution of a circular annulus and of a circular disk. The fourth approximations for the capacitance are in good agreement with the known exact values.

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.746 **2303**

The Magnetic Field Strength in Sunspots.—G. Thiessen. (*Naturwissenschaften*, April 1953, Vol. 40, No. 7, pp. 218–219.) Brief discussion of the validity of formulae developed by various investigators.

523.746 **2304**

The Sunspot Number Series.—R. N. Bracewell. (*Nature, Lond.*, 11th April 1953, Vol. 171, No. 4354, pp. 649–650.) Because of the lack of a truly periodic term in the sunspot-number series, predictions have so far been made on an empirical basis. A more satisfactory representation is obtained by plotting the numbers with reversed sign for alternate 11-year periods, to give a 22-year cycle with practically zero mean value. A significant degree of correlation is found between the slopes of adjacent flanks of the successive 11-year cycles.

550.384.3(99) **2305**

Mean Magnetic Field and Secular Variation in Adélie Land [from May 1951] **to 1st January 1952.**—P. N. Mayaud. (*C. R. Acad. Sci., Paris*, 2nd March 1953, Vol. 236, No. 9, pp. 954–956.)

551.510.535 **2306**

The Lower E and D Region of the Ionosphere as deduced from Long Radio Wave Measurements.—R. J. Nertney. (*J. atmos. terr. Phys.*, Feb. 1953, Vol. 3, No. 2, pp. 92–107.) An ionosphere model is proposed which is in reasonable agreement with experimental data. During the day this locates the 16-kc/s reflection region in the tail of the D layer around 75 km height, the ionosphere-winds region in the nose of the layer centred on 77 km, and a region of minimum ionization density between the D and E layers at about 80 km, with electron density of about 300 electrons/cm^3.

551.510.535 **2307**

The Longitude Effect in the F Region.—K. Rawer: C. M. Minnis. (*J. atmos. terr. Phys.*, Feb. 1953, Vol. 3, No. 2, pp. 123–124.) Further discussion. See also 1379 of 1951 (Rawer) and 3081 of 1952 (Minnis).

551.510.535 **2308**

Ionospheric Storms and the Geomagnetic Anomaly in the F$_2$ layer.—E. V. Appleton & W. R. Piggott. (*J. atmos. terr. Phys.*, Feb. 1953, Vol. 3, No. 2, pp. 121–123.) Graphs are shown of (*a*) hourly values of the ratio of critical frequency on magnetically disturbed days to that on quiet days for Wakkanai during the winter, (*b*) hourly values of the ratio of critical frequency at Ottawa to that at Wakkanai during the winter. The shape of the graphs is similar, indicating that the geomagnetic distortion anomaly in the F$_2$ layer is such that it causes a minimum of critical frequency in the forenoon and a maximum in the afternoon. For Huancayo the principal anomaly is the abnormal maintenance of high fF_2 values after sunset.

551.510.535 : 551.55 **2309**

Travelling Disturbances in the Ionosphere: Diurnal Variation of Direction.—G. H. Munro. (*Nature, Lond.*, 18th April 1953, Vol. 171, No. 4355, pp. 693–694.) Since the publication of previous papers (2504 of 1950) observations of greater accuracy and extending over a greater part of the day have provided definite evidence of diurnal variation in the direction of horizontal movement. This is most marked in the month of June. A graph is given which shows the median values of all directions observed for each hourly interval for all days of June in 1950, 1951 and 1952. A similar trend is noted in all three years, the direction of movement changing from about 50° (E of N) at 0930 to 15° at 1430. Recent night observations suggest that there is consistently an E-W component of movement at night, in contrast with the consistent W-E component in the daytime.

551.510.535 : 551.55 **2310**

Moving Clouds of Ionisation in Region E of the Ionosphere.—J. W. Findlay. (*J. atmos. terr. Phys.*, Feb. 1953, Vol. 3, No. 2, pp. 73–78.) During investigations of the phase path of 2·4-Mc/s radio waves returned from the E layer (397 of 1952) some 110 echoes were observed which came from equivalent heights rather less than that of the E layer. Analysis supports the interpretation that the echoes came from ionization clouds moving with constant velocity in a horizontal direction. Histograms show that the velocities ranged between 20 and 150 m/s, that the most probable duration was 4–5 min and the most probable height 95–110 km. Echoes can apparently be detected only from clouds lying within a cone of semi-angle 6° from the observing point, the average horizontal dimension of the clouds being about 700 m.

551.510.535 : 551.55 **2311**

The Heights of Ionospheric Winds as measured at Long Radio Wavelengths.—R. E. Jones, G. H. Millman & R. J. Nertney. (*J. atmos. terr. Phys.*, Feb. 1953, Vol. 3, No. 2, pp. 79–91.) The winds region is considered as constituting a 'screen' capable of altering the phase and amplitude of a radio wave passing through it. The field pattern at the ground is assumed to be such that information on the phase change and absorption experienced by a wave passing through the 'screen' can be obtained from it. It is also assumed that only the ordinary wave is observed, and that the region concerned is of the W.K.B. type. With these assumptions, theory is developed which, when applied to experimental data for 150-kc/s signals, gives the winds-region height as 74–77 km during the day and 83–100 km at night.

551.510.535 : 551.594.13 : 550.38 **2312**

Conductivity of the Ionosphere and Geomagnetic Tides.—I. Lucas. (*Naturwissenschaften*, April 1953, Vol. 40, No. 8, p. 239.) The results of various investigations are summarized and discussed, with particular reference to effects observed near the geomagnetic equator.

551.510.535 : 621.396.812 **2313**

The Investigation of Ionospheric Absorption by a New Automatic Method: Part 2 — Measurements on Oblique-Incidence Broadcast Signals.—J. B. Jenkins. (*Electronic Engng*, May 1953, Vol. 25, No. 303, pp. 189–190.) Apparatus similar to that described in part 1 (1680 of June) is used for recording the strength of a signal received from a distant transmitter by reflection from the ionosphere. Comparison of the vertical-incidence records with simultaneously obtained oblique-incidence records is expected to facilitate the investigation of winds in the ionosphere.

551.578.1/.4 : 621.396.9 **2314**

Scattering and Attenuation by Non-spherical Atmospheric Particles.—D. Atlas, M. Kerker & W. Hitschfeld. (*J. atmos. terr. Phys.*, Feb. 1953, Vol. 3, No. 2, pp. 108–119.) Gans' theory of e.m. scattering and absorption by ellipsoids is applied to atmospheric particles. If these have preferred orientations, the amount of back-scattered energy depends on particle shape and on orientation of the particle relative to the incident beam. The effect is negligible in the case of snow. If the particles have random orientations, the observed scattering is independent of aerial orientation, but greater for ellipsoidal shape and for water particles than for ice. These theoretical considerations account well for known 'melting-band' phenomena.

551.594.6 : 621.396.11 **2315**

Multiple Bursts of Signal in Long-Distance Very-High-Frequency Propagation.—Isted. (See 2419.)

LOCATION AND AIDS TO NAVIGATION

621.396.9 : 551.578.1/.4 **2316**

Scattering and Attenuation by Non-spherical Atmospheric Particles.—Atlas, Kerker & Hitschfeld. (See 2314.)

621.396.9 : 621.385.832 **2317**

A Quality Factor for Radar Cathode-Ray-Tube Presentations.—A. F. Bischoff. (*Proc. nat. Electronics Conf., Chicago*, 1952, Vol. 8, pp. 387–394.) A formula universally applicable to radar systems is derived which can be used to calculate a quality factor for the c.r.-tube display of a radar system. The quality factor expresses the effective brightness of the display in foot-lamberts. By converting to contrast ratio and referring to a family of empirical curves, perception time can be determined as a function of contrast ratio and c.r.-tube presentation size. Measurements on several modern radar equipments confirmed the value of this method of assessing their relative merits as regards display characteristics.

621.396.93 : 551.510.535 **2318**

A Problem of Radio Direction-Finding: Ionospheric Anisotropy.—G. Elghozi. (*Ann. Télécommun.*, March 1953, Vol. 8, No. 3, pp. 78–92.) The theories of Booker (714 of 1950) and Al'pert (1032 of 1948) on the magneto-ionic effect are outlined and their formulae for the resulting lateral deviation of e.m. waves are compared. The methods of calculation involved are equivalent; if the results obtained are not the same, this may be due to differences between the values of the parameters occurring in the formulae. These parameters include frequency, distance, azimuth of the initial plane of the wave, inclination of the geomagnetic field, value of the m.u.f. Their number precludes individual analysis. Several simple cases are, however, treated by Booker's method; the order of magnitude of the lateral deviations to be expected is determined and the conditions are found which the parameters must satisfy for the deviations to be appreciable.

621.396.932/.933 **2319**

Continuous-Indicating Loran.—R. B. Williams, Jr. (*Proc. nat. Electronics Conf., Chicago*, 1952, Vol. 8, pp. 365–375.) A description is given of a system in which the match of m.f. loran pulses in amplitude and in time difference, manually set up, is maintained over a very wide range of signal amplitudes. Each loran receiver of this modified type displays continuously a time-difference reading corresponding to a loran line of position, so that two such units determine the two lines of position necessary for a continuous navigational fix. Field tests have proved the system to be especially advantageous for use in aircraft.

621.396.932/.933/.2 **2320**

Phase and Gain Stabilization in Matched-Channel Receivers.—T. R. O'Meara & H. D. Webb. (*Proc. nat. Electronics Conf., Chicago*, 1952, Vol. 8, pp. 376–386.) Factors leading to mismatch of gain and phase characteristics are discussed. Careful matching of components, use of low-impedance selective circuits, use of fixed-tuned amplifiers wherever feasible, and use of automatic phase-matching are recommended. See also 999 of 1952 (Webb).

MATERIALS AND SUBSIDIARY TECHNIQUES

533.5 **2321**

Gettering Process of Barium: Sorption Properties of Oxygen to Barium.—T. Arizumi & S. Kotani. (*J. phys. Soc. Japan*, May/June 1952, Vol. 7, No. 3, pp. 300–307.)

535.215 : 546.431-31 **2322**

External Photoelectric Emission of Barium Oxide.—K. Noga & S. Kawamura. (*J. phys. Soc. Japan*, May/June 1952, Vol. 7, No. 3, pp. 287–291.) Measurements were made of the photoelectric emission from sprayed coatings of BaO on Ni over a range of temperatures. The results are discussed in terms of energy levels.

535.37 **2323**

Interaction of Manganese Activator Ions in Zinc-Orthosilicate Phosphors.—S. Larach & J. Turkevich. (*Phys. Rev.*, 1st March 1953, Vol. 89, No. 5, pp. 1060–1065.)

537.226 **2324**

Ferroelectricity in Oxides of Face-Centred Cubic Structure.—W. R. Cook, Jr, & H. Jaffe. (*Phys. Rev.*, 15th March 1953, Vol. 89, No. 6, pp. 1297–1298.) A fluorite structure was previously (1374 of May) ascribed to $Cd_2Nb_2O_7$ and $Pb_2Nb_2O_7$. It is now confirmed that the structure of $Cd_2Nb_2O_7$ is face-centred cubic, with dimensions double those of the fluorite structure. A strictly cubic pattern of unit cell has been found for a lead niobate deficient in lead.

537.226 **2325**

Variational Methods for Periodic Lattices and Artificial Dielectrics.—C. Flammer. (*Phys. Rev.*, 15th March 1953, Vol. 89, No. 6, p. 1298.)

537.226 : 621.3.029.64 **2326**

Waveguide Measurements in the Microwave Region on Metal Powders suspended in Paraffin Wax.—J. M. Kelly, J. O. Stenoien & D. E. Isbell. (*J. appl. Phys.*, March 1953, Vol. 24, No. 3, pp. 258–262.) Artificial dielectrics have been produced with refractive indices as high as 7·2 at a frequency of 9·364 kMc/s, by embedding tiny flakes of conducting material in paraffin wax. When good conductors such as Cu and Al are used, the permeability is complex and the permittivity substantially real. The observed results are in agreement with the theoretical results of Lewin (2139 of 1947). To obtain low loss and high refractive index with powdered conductors, the particles must be very small and highly polarizable.

537.311.32 **2327**

The Electrical Conductivity of MgO Single Crystals at High Temperatures.—A. Lempicki. (*Proc. phys. Soc.*, 1st April 1953, Vol. 66, No. 400B, pp. 281–283.) Measurements were made over the temperature range 300°–1 500°K; the results are shown graphically. The energy gap between the full and conduction bands is found to be 4·6 eV, assuming that the conduction is electronic and intrinsic.

537.311.33 **2328**

Preliminary Data on the Relations between Lattice Defects and Debye R.F. Absorption in Iron Oxides.—R. Freymann. (*J. Phys. Radium*, Feb. 1953, Vol. 14, No. 2, pp. 130–131.) At temperatures in the range 100°–273°K and frequency 1 Mc/s, Fe_3O_4-Fe_2O_3 mixtures are characterized by low absorption, FeO-Fe_3O_4 mixtures by high absorption.

537.311.33 : 537.312.8 **2329**

Theory of the Magnetoresistive Effect in Semiconductors.—V. A. Johnson & W. J. Whitesell. (*Phys. Rev.*, 1st March 1953, Vol. 89, No. 5, pp. 941–947.) Calculation shows that when account is taken of the scattering of conduction electrons by impurity ions as well as by the lattice, the discrepancy between theoretical and experimental values of the magnetoresistive effect is increased. The calculated magnetic-field effects are very much greater for an intrinsic semiconductor than for an impurity semiconductor. The fractional changes in resistivity and Hall coefficient are calculated, for several different values of the electron/hole mobility ratio, as functions of a parameter involving magnetic field strength and temperature. Experimental values of the magnetic-field effect in intrinsic semiconductors at high temperatures are not available for comparison.

537.311.33 : 546.289 **2330**

Microwave Observation of the Collision Frequency of Electrons in Germanium.—T. S. Benedict & W. Shockley. (*Phys. Rev.*, 1st March 1953, Vol. 89, No. 5, pp. 1152–1153.) Measurements were made of the attenuation and phase shift resulting from the introduction of a sample of Ge into the rectangular waveguide of a 1·24-cm microwave bridge. From the results obtained on two samples, of different resistivities, the effective mass and relaxation time caused by collisions of the conduction electrons are found to be about 0·6 times the free-electron mass and $6 \cdot 6 \times 10^{-9} T^{-1 \cdot 5}$ sec respectively, T being the absolute temperature.

537.311.33 : 546.289 **2331**

Radiative Transitions in Germanium.—J. B. Gunn. (*Proc. phys. Soc.*, 1st April 1953, Vol. 66, No. 400B, pp. 330–331.) Experiments are described which demonstrate the occurrence of radiation due to recombination of injected minority carriers. Two similar *n*-type Ge filaments were used, one as radiation source and the other as photoconductive detector. Holes were injected into the source filament in pulses, and were drawn along the filament by means of an applied field. On reversing the direction of this drift current, the detector output signal disappeared.

537.311.33 : 546.289 **2332**

The Temperature Dependence of Drift Mobility in Germanium.—R. Lawrance. (*Phys. Rev.*, 15th March 1953, Vol. 89, No. 6, p. 1295.) The method previously described by Lawrance & Gibson (1379 of May) was used to measure the drift mobility of holes in single-crystal *n*-type Ge in the temperature range 100°–360°K. The method involves the use of a direct emitter voltage and a pulsed sweeping field. With decreasing temperature the drift mobility increases at first and then decreases rapidly when trapping occurs. The traps are apparently on the surface and may be completely filled and made ineffective by illuminating the specimen with light from a tungsten-filament lamp. The temperature variation of drift mobility is proportional to $T^{-2 \cdot 3}$.

537.311.33 : 546.289 : 536.49 **2333**

Properties of Thermally Treated Germanium.—L. Esaki. (*Phys. Rev.*, 1st March 1953, Vol. 89, No. 5, pp. 1026–1034.) A detailed account is given of investigations of the changes of the rectification characteristic, the resistivity, and the Hall coefficient of *n*-type single-crystal Ge samples subjected to various heat treatments.

537.311.33 : 621.396.822 **2334**

Contact Noise in Semiconductors.—R. E. Burgess. (*Proc. phys. Soc.*, 1st April 1953, Vol. 66, No. 400B, pp. 334–335.) The result obtained by Macfarlane (910 of 1951) for the noise due to surface diffusion of ions into and out of strip-shaped patches is expressed in a simple closed form. For a circular patch the formula can also be expressed in closed form, on correction of an error in the original; but the noise-spectrum function then found differs from the approximate inverse-frequency form previously found.

537.32 **2335**

Thermoelectric Power for Very Small Differences of Temperature.—J. Savornin & F. Savornin. (*C. R. Acad. Sci., Paris*, 2nd March 1953, Vol. 236, No. 9, pp. 898–900.) Measurements of the thermoelectric power dE/dT of a sample of *p*-type Si at temperatures near 15°C, with progressively smaller values of dT, show that the values obtained are constant, even when dT is as low as 0·01°. This result differs from that of Sato for a semiconducting Bi-Sn alloy, for which dE/dT for a temperature difference of 0·5° was only 75% of the value for a difference of 3°.

537.533.8 **2336**

The Origin of Secondary-Emission Electrons.—A. Lempicki. (*Proc. phys. Soc.*, 1st April 1953, Vol. 66, No. 400B, pp. 278–280.) Experiments were made to determine the energy necessary to liberate secondary electrons, using a valve with a multiplier electrode coated with a mixture of BaO and MgO. The results indicate that the secondary electrons originate from the valence band and not from impurity centres.

538.221 **2337**

The Approach to Saturation in Dilute Ferromagnetics.—A. D. Franklin & A. E. Berkowitz. (*Phys. Rev.*, 15th March 1953, Vol. 89, No. 6, p. 1171.) For mixtures containing more than about 60% of 2-μ iron powder, Néel's theory was found valid. With decrease of iron content below 60%, the deviation from theory indicates that some other factor controls the approach to saturation.

538.221 **2338**

An Interpretation of the Magnetic Properties of some Iron-Oxide Powders: Part 2.—W. P. Osmond. (*Proc. phys. Soc.*, 1st April 1953, Vol. 66, No. 400B, pp. 265–272.) The intepretation previously offered (2528 of 1952) is revised to take account of the probable cavities in the powder particles caused by loss of oxygen during the various transformations. Good quantitative agreement is found between theoretical and measured values of coercivity, the value depending only on shape anisotropy.

538.221 **2339**

Influence of the Magnetic Field on a Polymorphic Transformation in a Ferromagnetic Material.—A. J. P. Meyer & P. Taglang. (*J. Phys. Radium*, Feb. 1953, Vol. 14, No. 2, pp. 82–84.)

538.221 **2340**

Quantum Theory of a Recently Suggested Cause of Ferromagnetism.—G. Heber. (*Ann. Phys., Lpz.*, 10th Oct. 1952, Vol. 11, No. 1, pp. 48–50.) A discussion of the mechanism of interaction between the 4*s* and 3*d* electrons in ferromagnetic materials. See also 2441 of 1951 (Zener).

538.221 **2341**

The Influence of Grain Size on Coercive Force.—A. Mager. (*Ann. Phys., Lpz.*, 10th Oct. 1952, Vol. 11, No. 1, pp. 15–16.) A brief discussion based on a highly simplified model of the domain structure.

538.221 : 621.318.2 **2342**

The Preferred Direction in a Magnetically Hardened Permanent-Magnet Alloy.—M. McCaig. (*J. appl. Phys.*, March 1953, Vol. 24, No. 3, p. 366.) Measurements are reported on columnar disks of alcomax III cut so that the columnar axis is along the diameter. In all cases the direction of easy magnetization lies between the hardening direction and the columnar axis.

538.222 : [546.732-31 + 546.712-31 **2343**

The Antiferromagnetic Properties of Mixed Cobalt and Manganese Oxides.—G. E. Bacon, R. Street & R. H. Tredgold. (*Proc. roy. Soc. A*, 8th April 1953, Vol. 217, No. 1129, pp. 252–261.)

538.652 : 538.221 **2344**

Magnetostriction in Alnico V.—J. R. Ireland. (*Electronics*, May 1953, Vol. 26, No. 5, pp. 234, 236.) The best magnetostrictive properties are obtained in alnico-5 by heat treatment followed by cooling at a controlled rate without application of a magnetic field. Subsequent drawing gives a slightly higher coercive force but reduces the magnetostrictive properties somewhat.

538.652 : 669.15.24-192 **2345**

Magnetic Crystal Anisotropy and Magnetostriction of Iron-Nickel Alloys.—R. M. Bozorth & J. G. Walker. (*Phys. Rev.*, 1st Feb. 1953, Vol. 89, No. 3, pp. 624–628.) Measurements on a number of Fe-Ni alloys show that the cooling rate after annealing has a large effect on the anisotropy for alloys with compositions near $FeNi_3$, where atomic ordering occurs. There is a smaller effect on the magnetostriction. The composition for highest initial and maximum permeabilities is nearly that for which the magnetostriction in the direction of easy magnetization is zero.

539.23 **2346**

Metallising of Glass, Ceramic and Plastic Surfaces.—R. J. Heritage & J. R. Balmer. (*Metallurgia, Manchr*, April 1953, Vol. 47, No. 282, pp. 171–174.) Three techniques for depositing metal films are discussed, namely, reduction from aqueous solutions, reduction by heat, and evaporation in a vacuum. Where necessary, the films can be subsequently thickened by electroplating. Various applications are indicated.

539.23 : 546.623-31 **2347**

Ionic Current and Film Growth of Thin Oxide Layers on Aluminium.—A. Charlesby. (*Proc. phys. Soc.*, 1st April 1953, Vol. 66, No. 400B, pp. 317–329.)

546.289 **2348**

Elasticity and Thermal Expansion of Germanium between − 195° and 275°C.—M. E. Fine. (*J. appl. Phys.*, March 1953, Vol. 24, No. 3, pp. 338–340.) The resonance frequencies of longitudinal and torsional vibrations in single-crystal Ge rods were measured. From these results and those of thermal-expansion measurements the Young's modulus and shear modulus were determined.

549.514.51 **2349**

Internal Friction of Quartz.—G. A. Alers. (*J. appl. Phys.*, March 1953, Vol. 24, No. 3, pp. 324–331.) The internal friction of quartz was investigated over the temperature range 200°–440°C by measuring the logarithmic decrement of a bar vibrating at its fundamental resonance frequency of 21 kc/s and at its second harmonic. The logarithmic-decrement/temperature curve obtained can be considered as a combination of two peaked curves, corresponding to relaxation effects, and an exponential curve.

621.314.634 **2350**

Electron Multiplication in Hard Flows of Selenium Rectifiers.—M. Tomura & Y. Abiko. (*J. phys. Soc. Japan*, March/April 1952, Vol. 7, No. 2, pp. 220–221.)

621.315.61 **2351**

Properties of Insulating Materials.—(*Elect. Times*, 26th March 1953, Vol. 123, No. 3203, pp. 582–585.) Brief report, with list of papers, of the Institution of Electrical Engineers Symposium. Recent work on solid and liquid insulants and researches on newly developed plastics were described.

621.315.61 **2352**

Silicone Resins in Insulation at Power Frequencies.—W. J. Renwick & J. R. Reed. (*Engineer, Lond.*, 27th March 1953, Vol. 195, No. 5070, pp. 471–473.) Shortened version of paper presented at the I.E.E. Symposium on Insulating Materials. Tests indicate that these materials are satisfactory at working temperatures at least 50°C higher than those permissible for conventional insulants.

621.315.61 **2353**

The Newer Laminated Plastic Insulating Materials.—A. N. Hawthorn & S. W. Messent. (*Engineer, Lond.*, 20th March 1953, Vol. 195, No. 5069, pp. 436–437.) Shortened version of paper presented at the I.E.E. Symposium on Insulating Materials. Measurements are reported of the properties of various laminated plastics. Effects of prolonged exposure to high temperature and high humidity are investigated.

621.315.611.017.143 **2354**

A New Method of Representing the Dielectric Losses in a Solid Insulating Material.—H. Bonifas. (*Rev. gén. Élect.*, March 1953, Vol. 62, No. 3, pp. 129–136.) A satisfactory representation of the losses in the dielectric of a capacitor is obtained by means of a resistor in series with the capacitor, with a second resistor in parallel with the combination. The loss factor of the capacitor is defined in terms of the two resistors; the corresponding vector diagrams are shown. The relative amounts of power dissipated in the two resistors are discussed and the optimum utilization of dielectric losses for dielectric heating is considered, with particular reference to the heating of a vitrifiable mixture and the gluing of wood.

621.318.4.042.15 **2355**

Moisture Aging of Powder-Core Toroids.—E. J. Oelbermann, R. E. Skipper & W. J. Leiss. (*Electronics*, May 1953, Vol. 26, No. 5, pp. 236 . . 242.) Test results indicate that absorption of moisture into the powder core of certain toroids decreases the inductance, which recovers again on removal of the moisture by vacuum drying. Hermetic sealing is recommended.

666.1.037.5 + 621.3.032.52/.53 **2356**

Hermetic Seals.—R. O. McIntosh. (*Elect. Mfg*, April 1952, Vol. 49, No. 4, pp. 120–123 . . 334.) Various types of seal, including glass-to-metal seals, are illustrated and discussed with special reference to their advantages and limitations.

669.245 : 621.385 **2357**

The Use of Nickel in Valves.—K. Jackson & R. O. Jenkins. (*Electronic Engng*, May 1953, Vol. 25, No. 303, pp. 208–211.) The general requirements for metals used in valve construction are discussed; Ni or a Ni alloy is found to satisfy these requirements in nearly all cases. The special requirements for use in cathodes, anodes, and grid and support wires are examined. Properties of Ni alloys used in valve components are listed.

535.215 **2358**

Photoconductivity in the Elements. [Book Review]—T. S. Moss. Publishers: Butterworths Scientific Publications, 1952, 249 pp., 50s. (*Electronic Engng*, May 1953, Vol. 25, No. 303, p. 222.) Results of theoretical and experimental research on photoconductivity are surveyed, and the results of the author's own investigations on a particular group of elements are presented.

621.315.6 + 537.311.33 + 538.221 **2359**

Radio Research Special Report No. 25. Selected Problems in the Preparation, Properties and Application of Materials for Radio Purposes. [Book Notice]—Publishers: H.M. Stationery Office, London, 1952, 1s. 6d. (*Govt Publ., Lond.*, March 1953, p. 25.)

MATHEMATICS

517.544.2 + 517.2 + 517.511](083.6) **2360**

Tables of Green's Functions, Fourier Series, and Impulse Functions for Rectangular Co-ordinate Systems.—J. J. Smith. (*Trans. Amer. Inst. elect. Engrs*, 1951, Vol. 70, Part I, pp. 22–30.) Tables based on a previous paper (1025 of 1945) are given which materially reduce the work of solving partial differential equations encountered in problems of engineering and physics.

517.93 **2361**

Stability Investigation of the Nonlinear Periodic Oscillations.—C. Hayashi. (*J. appl. Phys.*, March 1953, Vol. 24, No. 3, pp. 344–348.)

519.242 **2362**

Interpolation in a Series of Correlated Observations.—E. J. Williams & N. H. Kloot. (*Aust. J. appl. Sci.*, March 1953, Vol. 4, No. 1, pp. 1–17.) Least-squares formulae are given for estimating the values of unmeasured members of a series from measurements of the alternate members; the series considered corresponds to a stationary random process, possibly with a linear trend. The applicability of three simple formulae, appropriate under different limiting conditions, is discussed; results obtained by applying different estimation formulae to experimental data are compared.

681.142 **2363**

Fundamental Characteristics of Digital and Analog Units.—J. M. Salzer. (*Proc. nat. Electronics Conf., Chicago*, 1952, Vol. 8, pp. 621–628.)

681.142 **2364**

A Different Approach to Analog Computation.—C. R. Bonnell. (*Proc. nat. Electronics Conf., Chicago*, 1952, Vol. 8, pp. 629–635.) Theory and description of computers based on the balancing of torques applied to a shaft, the torques representing various parameters. For a shorter account, see *Radio & Telev. News, Radio-Electronic Engng Section*, May 1953, Vol. 49, No. 5, pp. 14–15, 31.

681.142 **2365**

Interconversion of Analog and Digital Data in Systems for Measurement and Control.—B. Lippel. (*Proc. nat. Electronics Conf., Chicago*, 1952, Vol. 8, pp. 636–646.)

681.142 **2366**

A Five-Channel Electronic Analog Correlator.—M. J. Levin & J. F. Reintjes. (*Proc. nat. Electronics Conf., Chicago*, 1952, Vol. 8, pp. 647–656.)

681.142 **2367**

A Diode-Bridge Limiter for Use with Electronic Analogue Computers.—R. J. Medkeff & R. J. Parent. (*Trans. Amer. Inst. Elect. Engrs*, 1951, Vol. 70, Part I, pp. 913–916.) Description of a simple limiter, developed from the basic diode-bridge circuit, which provides an absolute limit and can be adjusted by means of a single control.

681.142 **2368**

A New Digital Computor.—(*Electronic Engng*, May 1953, Vol. 25, No. 303, p. 201.) Brief description of the '401' computer, built on the sub-unit principle.

681.142 **2369**

An Electronic Statistical Tabulator.—R. M. Stewart, Jr, & A. R. Kassander, Jr. (*Proc. nat. Electronics Conf., Chicago*, 1952, Vol. 8, pp. 657–667.)

681.142 **2370**

High-Speed Number Generator uses Magnetic Memory Matrices.—An Wang. (*Electronics*, May 1953, Vol. 26, No. 5, pp. 200 . . 204.) Description of equipment for displaying numbers on the screen of a c.r. tube.

681.142 **2371**

The Input-Output System of the EDVAC.—R. L. Snyder, Jr. (*Trans. Amer. Inst. elect. Engrs*, 1951, Vol. 70, Part I, pp. 507–509.)

681.142 : 517.93 **2372**

Analog Computer Elements for Solving Nonlinear Differential Equations.—C. A. Ludeke & C. L. Morrison. (*J. appl. Phys.*, March 1953, Vol. 24, No. 3, pp. 243–248.)

681.142 : 621.314.7 **2373**

A Transistor Optical Position Encoder and Digit Register.—H. G. Follingstad, J. N. Shive & R. E. Yaeger. (*Proc. nat. Electronics Conf., Chicago*, 1952, Vol. 8, pp. 766–775.) See 766 of March.

681.142 : 621.318.57 **2374**

A Method of Gating for Parallel Computers.—A. G. Ratz & V. G. Smith. (*Trans. Amer. Inst. elect. Engrs*, 1951, Vol. 70, Part I, pp. 510–516.)

681.142 : 621.396.6 **2375**

Circuitry 'Packages' for Electronic Computers.—(See 2263.)

MEASUREMENTS AND TEST GEAR

621.3.018.41(083.74) **2376**

Developments in Frequency Synthesis.—H. J. Finden. (*Electronic Engng*, May 1953, Vol. 25, No. 303, pp. 178–183.) Extension of work noted in 2261 of 1944 and 1961 of 1950. Accurate frequencies in the range 1 kc/s–100 Mc/s are obtained by combining in a mixer system the harmonics of a decade system of frequencies derived by division and multiplication from an internal or external 100-kc/s frequency standard. The harmonics are selected in relation to the frequency to be synthesized so that unwanted mixer products can be filtered out.

621.3.018.41.029.426 : 621.3.087 **2377**

An Automatically Calibrated Electronic Frequency Recorder.—W. E. Phillips. (*Proc. nat. Electronics Conf., Chicago*, 1952, Vol. 8, pp. 781–786.) Description of equipment particularly suitable for industrial applications requiring maintenance of stable speeds over long periods. A pulsating voltage, either a.c. or d.c., is developed by any convenient means and used to generate a succession of uniform positive voltage pulses whose average value, applied to a capacitor, is a measure of the original speed and is recorded on a Speedomax recorder whose calibration is checked automatically every 45 minutes. The frequency range covered is 10–130 c/s.

621.3.087.6 : [621-526 : 621.396.615 **2378**

A Servo System for Heterodyne Oscillators.—T. Slonczewski. (*Trans. Amer. Inst. elect. Engrs*, 1951, Vol. 70, Part I, pp. 1070–1072.) Full paper. See 720 of 1952.

621.3.087.6 : 621.3.015.7 **2379**

Test Set for Recording Impulses.—L. J. Nijs. (*Elect. Commun.*, March 1953, Vol. 30, No. 1, pp. 9–11.) Description of portable equipment producing a record on waxed paper tape of two independent impulse inputs and a timing trace. A timing precision to within 2 ms is obtained, neglecting errors due to supply frequency deviations.

621.317.335 : 621.315.61 **2380**

On the New Method of Measuring Dielectric Constant and Loss Angles of Semiconductors.—B. Ichijo. (*J. appl. Phys.*, March 1953, Vol. 24, No. 3, pp. 307–311.) A description is given of the 'double-resonant-circuit' method, which is useful for investigating poor insulators such as wood or textile containing much moisture. Measurement results are discussed.

621.317.335.3 + 621.317.411].029.64 **2381**

A Method of Measuring Dielectric Constant and Complex Permeability at Ultra-high Frequencies.—A. Surduts. (*C. R. Acad. Sci., Paris*, 2nd March 1953, Vol. 236, No. 9, pp. 900–902.) Detailed theory, with derivation of the formulae necessary for numerical calculation, is presented for a method in which the material to be tested completely fills a short portion of a waveguide matched to an u.h.f. source. For measurements of the dielectric constant, the method is similar to that of Roberts & von Hippel (178 of 1947), the waveguide being short-circuited behind the material. For the permeability measurement, a matched section, with the same characteristic impedance as that of the waveguide in front of the material, is used behind the material, an absorbing cone eliminating the reflected wave.

621.317.335.3 : 621.396.611.4 **2382**

Determination of the Dielectric Constants of Optically Uniaxal Crystals from the Spectrum of Natural Oscillations of Circular-Cylinder Cavity Resonators.—E. Hafner. (*Arch. elekt. Übertragung*, April 1953, Vol. 7, No. 4, pp. 181–190.) An examination is made of the field pattern inside a resonator containing a disk of the crystal, and the equations for the natural electric and magnetic modes (1623 of June) are discussed. Various methods are indicated for determining the two principal dielectric constants of the crystal from the geometry of the system when the particular mode of oscillation is known.

621.317.351 : 621.3.018.78 **2383**

Diagnosis of Distortion. The 'Difference Diagram' and its Interpretation.—E. R. Wigan. (*Wireless World*, June 1953, Vol. 59, No. 6, pp. 261–266.) The distorted output signal from equipment under test is passed through a network which subtracts the fundamental wave and leaves only the distortion terms plus any hum or other circuit noise. This, after amplification, is applied to the y plates of a c.r.o. By suitable adjustment of the phase of the signal applied to the x plates, a curved line trace is obtained which is a representation of the circuit transfer characteristic with all its defects much magnified. By comparing this 'difference diagram' with certain standard shapes, examples of which are given, the various sources of distortion in particular circuits can be recognized and corrective measures applied. Typical oscillograms are reproduced.

621.317.365 **2384**

Measuring Wavelength in Millimeters.—J. R. Martin & C. F. Schunemann. (*Electronics*, May 1953, Vol. 26, No. 5, pp. 184–187.) Wavelength measurements were made on klystron and magnetron sources and on a Righi doublet of length 1 cm. Three methods were used: (*a*) diffraction-grating spectrometer; (*b*) Boltzmann interferometer; (*c*) Michelson interferometer. Details of the various components of the equipment used are described and measurement results are tabulated, with estimates of probable errors. The Michelson interferometer results are the most consistent and this system appears to be the most convenient of the three systems used. It can easily be extended to much shorter wavelengths than those now reported, which were of the order of 1·25 or 3 cm.

621.317.7 : 621.314.7 : 621.396.822 **2385**

Noise Analyzer for Transistor Production.—R. F. Merrithew. (*Electronics*, May 1953, Vol. 26, No. 5, pp. 136–137.) Description, with full circuit details, of an instrument designed to measure transistor noise figures at a frequency of 1 kc/s and 1-c/s bandwidth. Calibrated attenuators give the required noise figure directly.

621.317.7.029.64 **2386**

An Ultrahigh-Frequency Discriminator.—G. Raoult & R. Fanguin. (*C. R. Acad. Sci., Paris*, 16th March 1953, Vol. 236, No. 11, pp. 1143–1145.) Description of frequency-stabilized equipment for measurements at 3-cm wavelength, based on well-known f.m. techniques. An error voltage is derived by means of a suitably coupled cavity resonator, magic-T junction and wide-band directional coupler and, after amplification, is applied to the klystron reflector.

621.317.715 : 537.324 **2387**

The Problem of Matching a Thermocouple to a Galvanometer.—L. Geiling. (*Ann. Télécommun.*, March 1953, Vol. 8, No. 3, pp. 103–112.) Factors limiting the sensitivity of the combination of a thermocouple and galvanometer are discussed. A projected instrument is described, termed a thermogalvanometer, which may have advantages over the thermocouple-galvanometer combination.

621.317.715.5 **2388**

A Transformer-Coupled Resonance Galvanometer.—H. G. Möller. (*Elektrotech. Z., Edn A*, 1st March 1953, Vol. 74, No. 5, pp. 150–151.) Description of a vibration galvanometer with bifilar-suspended coil, suitable for use with an a.c. bridge. The suspension can be adjusted to give high sensitivity at an appropriate frequency.

621.317.72.088.2 **2389**

Influence of the Ground on the Calibration and Use of V.H.F. Field-Intensity Meters.—F. M. Greene. (*Proc. Instn Radio Engrs, Aust.*, March 1953, Vol. 14, No. 3, pp. 58–64.) Reprint. See 2284 of 1950.

621.317.73 : 621.396.611.21 **2390**

Crystal Impedance Meters replace Test Sets.—A. C. Prichard & M. Bernstein. (*Electronics*, May 1953, Vol. 26, No. 5, pp. 176–180.) Two impedance meters for testing crystal units have been developed in the U.S. Signal Corps engineering laboratories: (*a*) Type TS-537/TSM, covering the frequency range 75 kc/s–1·1 Mc/s; (*b*) Type TS-330/TSM, covering the range 1–15 Mc/s. Each instrument can be used to test crystal units at resonance or at antiresonance over a range of load capacitance from 12 pF to 120 pF. A projected test set, Type TS-683/TSM, is primarily intended for resonance measurements in the range 10–75 Mc/s. A circuit diagram is given for the 1–15-Mc/s instrument. The impedance meter is essentially a tuned-grid tuned-anode oscillator in which the crystal unit to be tested is connected in the main feedback path, so that it controls the oscillation frequency and amplitude. The crystal-unit parameters are determined by a substitution method, a resistor replacing the crystal unit and being adjusted so that the oscillation frequency and amplitude are the same when either the crystal unit or the resistor is in circuit. The other parameters of the crystal unit are then determined from formulae which are given in an appendix.

621.317.733.018.12 **2391**

Phase Bridge for Measurement and Display of Phase Distortions in Television Apparatus (Phasograph).—H. Fegert. (*NachrTech.*, March 1953, Vol. 3, No. 3, pp. 111–115.) Design requirements for a universal, fully automatic phase bridge suitable for measurements on filters, amplifiers, cables, or quadripoles of any kind, are discussed. A description is given of equipment of this type, with illustrations of its use for measuring the delay of a 2-stage band-pass filter.

621.317.735 : 621.315.21 **2392**

A New Cable-Fault Indicator.—M. B. Williams & D. Brookes. (*P.O. elect. Engrs' J.*, April 1953, Vol. 46, Part 1, pp. 13–18.) Description of equipment which gives an alarm signal when the insulation resistance falls below a prescribed value.

621.317.742.029.64 : 621.315.212 **2393**

U.H.F. Cable Measuring Equipment.—W. W. H. Clarke, J. L. Goldberg & J. D. S. Hinchliffe. (*A.T.E. J.*, April 1953, Vol. 9, No. 2, pp. 100–108.) Description, with photographs, of equipment using a slotted coaxial-line unit, with tapered matching units, for the impedance measurements required for determination of coaxial-cable irregularities.

621.317.784 : 621.316.313 **2394**

A Thermocouple Audio-Frequency Wattmeter.—J. D. Ryder & M. S. McVay. (*Proc. nat. Electronics Conf., Chicago*, 1952, Vol. 8, pp. 725–729.) Theory and description of an instrument using thermocouples as the squaring and averaging elements. With careful design, operation is satisfactory in the range 50 c/s–15 kc/s. See also *Radio & Telev. News, Radio-Electronic Engng Section*, Feb. 1953, Vol. 49, No. 2, pp. 6–7, 20.

621.396.645.35 : 621.317.32 **2395**

Operation and Properties of a New Direct-Voltage Amplifier using W. Kroebel's Crystal Contact Breaker.—G. Haas. (*Z. angew. Phys.*, March 1953, Vol. 5, No. 3, pp. 107–116.) An amplifier is discussed in which the direct-voltage input is converted to alternating voltage by means of the contact breaker previously described [787 of March (Kroebel)], damped trains of oscillations being set up in a *CL* input circuit. Design for high sensitivity with high input resistance is investigated theoretically and experimentally. The construction is described of an amplifier with input resistance > 1 000 MΩ, with an operating threshold three times the value of the noise voltage corresponding to the 100-MΩ internal resistance of the source.

621.397.6.001.4 **2396**

Television Test Equipment.—L. W. Mittelmann. (*NachrTech.*, March 1953, Vol. 3, No. 3, pp. 116–120.) A translation from *Radiotekhnika, Moscow*, 1951, No. 6, pp. 48–60. Equipment is described, with block diagrams and some schematic circuit diagrams, suitable for adjustment of the frequency characteristics of wide-band amplifiers in the range 0·1–20 Mc/s, for alignment of television receivers in the range 6–80 Mc/s, and for pulse testing of television receivers, using pulse rise times down to 0·05 μs.

621.397.62.001.4 **2397**

Measurements on Television Receivers: Part 1—General Survey.—O. Macek. (*Arch. tech. Messen*, Feb. 1953, No. 205, pp. 41–42.) Receiver circuits and the 625-line and 525-line standards are reviewed as a preliminary to the discussion of appropriate receiver tests.

621.317.7 **2398**

Electrical Measuring Instruments: Part 1. [Book Review]—C. V. Drysdale & A. C. Jolly, revised by G. F. Tagg. Publishers: Chapman & Hall, 2nd edn 1952, 279 pp., 75s. (*Electronic Engng*, May 1953, Vol. 25, No. 303, p. 221.) Revised edition of a standard work.

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

531.768 : 546.431.824-31 **2399**

A Ceramic Vibration Pick-Up.—E. V. Carlson. (*Proc. nat. Electronics Conf., Chicago*, 1952, Vol. 8, pp. 94–98;

Radio & Telev. News, Radio-Electronic Engng Section, May 1953, Vol. 49, No. 5, pp. 8–9, 27.) The advantages resulting from the use of polarized multicrystal $BaTiO_3$ ceramic instead of Rochelle salt in vibration pickups are discussed. The construction of a $BaTiO_3$ unit is described and a practical reciprocity method of calibration, using three of the units, is illustrated by a numerical example.

534.1.08 **2400**

Vibration Measurements.—D. S. Gordon: R. Winslade. (*Electronic Engng*, May 1953, Vol. 25, No. 303, pp. 216–217.) Comment on 790 of March and author's reply.

534.321.9 : 623.896 **2401**

An Acoustic Liquid-Depth Recorder.—C. E. Goodell. (*Proc. nat. Electronics Conf., Chicago*, 1952, Vol. 8, pp. 776–780.) See 1447 of May.

534.321.9 : 669 **2402**

Some Metallurgical Applications of Ultrasonics.—A. E. Crawford. (*Metallurgia, Manchr*, March 1953, Vol. 47, No. 281, pp. 109–113.) The design of suitable generators is discussed and various applications, particularly in the foundry, are indicated.

548.0 : 537.228.1 : 001.8 **2403**

Piezoelectric Crystals as Sensing Elements of Pressure, Temperature, and Humidity.—E. A. Roberts & P. Goldsmith. (*Trans. Amer. Inst. elect. Engrs*, 1951, Vol. 70, Part I, pp. 968–972.) Full paper. See 1058 of 1952.

621.317.083.7 **2404**

Pulse-Time Modulation Telemetering Systems for Rocket Application.—J. T. Mengel. (*Trans. Amer. Inst. elect. Engrs*, 1951, Vol. 70, Part I, pp. 599–605.) Design and operational data are presented for a 23-channel telemetry system with a peak pulse power of 1 kW, and for an improved 30-channel system with 4-kW peak pulse power.

621.384.6 **2405**

Elimination of the Effects of Faulty Alignment in the Strong-Focusing Cosmotron [proton synchrotron].—J. Seiden. (*C. R. Acad. Sci., Paris*, 16th March 1953, Vol. 236, No. 11, pp. 1145–1146.) Choice of suitable operating point will eliminate the particle loss involved in the design proposed by Courant et al. (1454 of May).

621.384.612 **2406**

A Focusing Method for Large Accelerators.—T. Kitagaki. (*Phys. Rev.*, 1st March 1953, Vol. 89, No. 5, pp. 1161–1162.) Theory is given of a method similar to that described by Courant et al. (1454 of May). A system of alternate guiding magnets and focusing magnets is used, the latter of the quadrupole type and located in the linear portion of the orbit.

621.384.622.2 **2407**

A 3–4-MeV Linear Electron Accelerator.—J. Vastel. (*C. R. Acad. Sci., Paris*, 30th March 1953, Vol. 236, No. 13, pp. 1343–1345.) Measurements are reported on a more powerful waveguide accelerator developed from the model previously described (2294 of 1952).

621.384.622.2 **2408**

Dielectric Loading for Waveguide Linear Accelerators.—G. T. Flesher & G. I. Cohn. (*Trans. Amer. Inst. elect. Engrs*, 1951, Vol. 70, Part I, pp. 887–893.) Relations are determined between the electric accelerating field and the input power, guide dimensions, frequency, and physical properties of the materials, for waveguide accelerating systems in which the loading takes the form of a coaxial dielectric cylinder, losses being taken into account.

621.385.833 **2409**

Electrostatic Lenses for Focusing High-Energy Particles: Calculation of Trajectories.—M. Y. Bernard. (*C. R. Acad. Sci., Paris*, 2nd March 1953, Vol. 236, No. 9, pp. 902–904.)

621.385.833 **2410**

Some Characteristics of a Low-Voltage Electron Immersion Objective.—W. W. H. Clarke & L. Jacob. (*Proc. phys. Soc.*, 1st April 1953, Vol. 66, No. 400B, pp. 284–295.) Report on an experimental investigation of the beam characteristics for electron guns operated at voltages in the range 20–70 V.

621.387.424 **2411**

The End Effects in Geiger Mueller Counters.—R. Ito. (*J. phys. Soc. Japan*, May/June 1952, Vol. 7, No. 3, pp. 256–260.)

621.395.61 : 621.317.083.7 **2412**

An Electromechanical Transducer.—J. F. Engelberger & H. W. Kretsch. (*Trans. Amer. Inst. elect. Engrs*, 1951, Vol. 70, Part I, pp. 213–216.) Description, with illustrations of its application, of a device suitable for converting mechanical and certain electrical quantities into corresponding electric currents, mainly for telemetry purposes. See also 693 of 1948 (Roper & Engelberger).

PROPAGATION OF WAVES

538.566 **2413**

A Transient Magnetic Dipole Source in a Dissipative Medium.—J. R. Wait. (*J. appl. Phys.*, March 1953, Vol. 24, No. 3, pp. 341–343.) Formulae are derived for the electric field due to a small current-carrying loop immersed in a dissipative medium and energized by a step-function current. Approximate expressions for the magnetic-field components are also derived. The propagation of an e.m. pulse in sea water is discussed.

621.396.11 **2414**

Approximate Determination of the Range at the Earth's Surface between Radio Transmitter and Receiver Installations.—O. Laaff. (*Fernmeldetech. Z.*, April 1953, Vol. 6, No. 4, pp. 169–171.) A diagram is constructed which facilitates calculation of service range for the case where the received signal is a combination of the direct wave and that reflected from the earth with a reflection coefficient of −1. A numerical example is worked out for a 5-kW television transmitter operating in the 200-Mc/s frequency band.

621.396.11 **2415**

A Note on Wave Propagation through an Inhomogeneous Medium.—G. A. Hufford. (*J. appl. Phys.*, March 1953, Vol. 24, No. 3, pp. 268–271.) The problem of computing the e.m. field due to radiation from an aerial near the ground is considered. A modification of Kirchhoff's formula is suggested and an equation is derived from which, if certain integrals can be evaluated, an estimate can be made of the error in the usual approximate methods. The theory is applied to the equivalent-earth's-radius model and to the flat-earth modified-index model.

621.396.11 : 551.510.52 **2416**

Tropospheric Propagation: a Selective Guide to the Literature.—(*Proc. Inst. Radio Engrs*, May 1953, Vol. 41, No. 5, pp. 588–594.) A paper prepared by a subcommittee of the I.R.E. to assist radio engineers who have not specialized in tropospheric propagation but wish for information on specific problems relating thereto. 41 references.

621.396.11 : 551.510.535 **2417**

Ionosphere Conditions and Radio Weather.—B. Beckmann. (*Elektrotech. Z., Edn A*, 1st March 1953, Vol. 74, No. 5, pp. 125–129.) The effect of ionosphere conditions on radio propagation is related to the width of the frequency band between the lowest useful h.f. and the m.u.f., and the mean received field strength for a given path. The product of these two factors is expressed as a single number and can be represented for day-time and night-time conditions on a clock-face diagram, an increase in this number indicating an improvement in conditions. Examples are shown.

621.396.11 : 551.510.535 **2418**

The Reflection of Radio Waves from an Ionized Layer having both Vertical and Horizontal Ionization Gradients.—R. P. W. Lewis. (*Proc. phys. Soc.*, 1st April 1953, Vol. 66, No. 400B, pp. 308–316.) Approximate transmission-path calculations are made, based on ray optics, neglecting effects due to the geomagnetic field and to ionospheric absorption, and considering only the case in which the plane of incidence contains the direction of the horizontal gradient. Two particular types of electron-density distribution are considered. The accuracy and limitations of the analysis are examined. Graphs are presented showing the dependence on angle of incidence of (*a*) angle of emergence, (*b*) increase in horizontal range due to the horizontal gradient, and (*c*) ratio of penetration frequencies with and without a horizontal gradient.

621.396.11 : 551.594.6 **2419**

Multiple Bursts of Signal in Long-Distance Very-High-Frequency Propagation.—G. A. Isted. (*Nature, Lond.*, 4th April 1953, Vol. 171, No. 4353, pp. 617–618.) Observations on 53·25-Mc/s signals made at a distance of 330 miles from the transmitter showed, in addition to a slowly varying continuous signal, pairs of bursts having a time separation of 0·7–6 sec and trains of three or four bursts having a constant time separation. These have been found to follow a lightning flash. This suggests that the mechanism is a relatively local recurrent condition of the medium consequent upon a flash. Eckersley's whistlers (*Nature, Lond.*, 1928, Vol. 122, p. 768) seem to be closely related phenomena.

621.396.11 : 621.396.67 **2420**

Ground-Reflection Phase-Error Characteristics of a Vertical Antenna.—Greenberg & Meierdiercks. (See 2221.)

621.396.11.029.55 **2421**

Meteor Scatter: a Newly Discovered Means for Extended-Range Communication in the 15- and 20-Meter Bands.—O. G. Villard, Jr, & A. M. Peterson. (*QST*, April 1953, Vol. 37, No. 4, pp. 11–15, 126.) See 2117 of July (Villard et al.).

621.396.11.029.6 : 551.510.535 **2422**

A Review of V.H.F. Ionospheric Propagation.—M. G. Morgan. (*Proc. Inst. Radio Engrs*, May 1953, Vol. 41, No. 5, pp. 582–587.) A review, prepared by a subcommittee of the I.R.E., of the characteristics of ionospheric propagation which utilizes (*a*) regular F_2 ionization, (*b*) sporadic E ionization, (*c*) scattering from the regular ionization, (*d*) auroral ionization, (*e*) meteoric ionization. 67 references.

621.396.11.029.63 **2423**

An Experimental Study of Wave Propagation at 850 Mc/s.—J. Epstein & D. W. Peterson. (*Proc. Inst. Radio Engrs*, May 1953, Vol. 41, No. 5, pp. 595–611.) A study was made of the effects of refraction, earth reflection, diffraction and attenuation on the effective range of an 850-Mc/s transmitter. The results obtained enable a satisfactory estimate to be made of the service area of a transmitter from the theoretical free-space field strength, when diffraction effects and certain other factors based on experiment are taken into account.

621.396.812.3 **2424**

Statistical Analysis of Field-Strength Fluctuations in the First Fading Zone of the Swiss Broadcasting Stations since the Implementation of the Copenhagen Plan.—C. Glinz. (*Tech. Mitt. schweiz. Telegr.-TelephVerw.*, 1st April 1953, Vol. 31, No. 4, pp. 106–114. In French and German.) Continuation of the work noted in 2816 of 1951, in which measurements were reported for operation at the frequencies allocated by the Lucerne Plan of 1934. For Beromünster and Sottens (frequencies changed from 556 to 529 kc/s and from 677 to 764 kc/s respectively) the new measurements show only small differences, while for Monte Ceneri (frequency changed from 1167 to 557 kc/s) the fading curve is completely changed and resembles that for Beromünster, thus confirming the preliminary report. Correlation with the sunspot cycle is not strong. The results cannot be clearly interpreted until night-time data for the ionosphere for medium frequencies are available.

RECEPTION

621.396.62.029.58 : 621.396.41 : 621.396.619.24 **2425**

Single-Sideband Multi-Channel Operation of Short-Wave Point-to-Point Radio Links: Part 3—An Independent-Sideband Short-Wave Radio Receiver.—W. R. H. Lowry & W. N. Genna. (*P.O. elect. Engrs' J.*, April 1953, Vol. 46, Part 1, pp. 19–24.) The design, construction and performance are described of a receiver suitable for long-distance links operating in the range 4–30 Mc/s, and designed for reception of the type of signal described in part 2 [2175 of July (Owen & Ewen)]. Response is uniform to within 2 db from 100 c/s to 6 kc/s. The receiver closely approaches the limits of performance theoretically obtainable in respect of sensitivity, faithful reproduction, and freedom from avoidable interference.

621.396.621 **2426**

An Audio-Frequency Mixing System for Spaced Diversity Receivers.—E. G. Hamer & D. W. Elson. (*J. Brit. Instn Radio Engrs*, Feb. 1953, Vol. 13, No. 2, pp. 123–128.) The general principles of diversity reception are reviewed and a suitable method of combining the outputs of spaced receivers is described. The average noise level remains sensibly constant over the receiver bandwidth. If a noise sample is taken from the a.f. output of a receiver, at a frequency outside the speech-frequency band, the information from this sample can be used at the central station to control the output level of the satellite receiver. The combined output of all the receivers fluctuates only to a small extent. Equipment based on this principle and designed for a 3-channel mobile f.m. v.h.f. service is described.

621.396.621 : 621.396.619.11/.13 **2427**

New Trends in A.M./F.M. Receiver Design.—H. H. van Abbe, B. G. Dammers, J. Haantjes & A. G. W. Uitjens. (*Electronic Applic. Bull.*, Dec. 1951, Vol. 12, No. 12, pp. 209–229.) The special requirements of a.m./f.m. receivers are discussed and a detailed description, with complete circuit diagram, is given of a receiver with five valves (plus a rectifier) three of which are new types. Type EABC80 is a triple-diode triode, Type-ECH81 a triode heptode and Type-EF85 a variable-μ high-slope pentode. Technical data for these valves are tabulated.

621.396.621.029.6 **2428**

The Development of Circuit and Valves for U.S.W. Receivers.—H. Rothe. (*Elektrotech. Z., Edn A*, 1st March 1953, Vol. 74, No. 5, pp. 161–165.) A review of German practice in receiver design. Advantages of different detector, demodulator and mixer circuits are discussed, and details are given of valves used, including a triple-diode triode for use as combined a.m./f.m. detector and a.f. preamplifier.

621.396.622 : 621.396.822 **2429**

The Detection of a Sine Wave in Gaussian Noise.—E. Reich & P. Swerling. (*J. appl. Phys.*, March 1953, Vol. 24, No. 3, pp. 289–296.) An analysis is made to determine the 'optimum' method of detecting a sine wave of known frequency and amplitude. The 'optimum' method is defined as that which gives maximum probability of recognizing the presence of the sine wave, while the probability of falsely indicating the presence of a sine wave does not exceed a given value. When the noise has a uniform frequency distribution, all the relevant information is contained in the amplitude and phase of the Fourier transform of the received sample at the frequency of the sine wave. When the noise has an exponentially decaying autocorrelation function the values at the end points of the observed sample are also significant.

621.396.82 **2430**

Interference Evaluation by means of Different Noise Filters.—E. Altrichter. (*NachrTech.*, Feb. 1953, Vol. 3, No. 2, pp. 80–82.) An examination is made of the difference between the results obtained by using the 1934 and 1949 C.C.I.R. curves and the D.I.N.-5045 curves for interference evaluation. Numerical results are given for the case of white noise.

621.396.823 **2431**

Radio Influence Tests in Field and Laboratory — 500-kV Test Project of the American Gas and Electric Company.—G. D. Lippert, W. E. Pakala, S. C. Bartlett & C. D. Fahrnkopf. (*Trans. Amer. Inst. elect. Engrs*, 1951, Vol. 70, Part 1, pp. 251–265. Discussion, pp. 265–269.) Full paper. See 257 of 1952.

STATIONS AND COMMUNICATION SYSTEMS

621.39.001.11 **2432**

New Problems and Methods in Communication Research. Report on the 'Symposium on Applications of Communication Theory' held in London.—W. Meyer-Eppler. (*Arch. elekt. Übertragung*, April 1953, Vol. 7, No. 4, pp. 201–206.) General discussion of the research trends indicated. A list of the papers given is included. See also *Fernmeldetech. Z.*, April 1953, Vol. 6, No. 4, pp. 189–190.

621.391 : 621.396.619.16 **2433**

Recent Development in Communication Technique.—C. W. Earp. (*Elect. Commun.*, March 1953, Vol. 30, No. 1, pp. 61–70.) Reprint. See 2889 of 1952.

621.394.4 : 621.395.44 **2434**

F.M. Telegraphy on Carrier-Current Telephone Lines.—B. Vural. (*Tech. Mitt. schweiz. Telegr.-TelephVerw.*, 1st April 1953, Vol. 31, No. 4, pp. 89–106. In German.) An investigation was made of the possibility of establishing a multichannel frequency-shift telegraphy system using the frequency band 8–12 kc/s. A single channel was tested in the laboratory. The bandwidth required is greater than that for the tone-frequency system, but the signal/noise ratio is better and the system is relatively insensitive to variations of attenuation with frequency. Using for each channel two frequencies separated by 300 c/s, the available band accommodates six channels.

621.395.44 : 621.315.052.63 **2435**

The Weser-Ems Power-Supply Carrier-Frequency Communication Network.—E. Koch. (*A.E.G. Mitt.*, July/Aug. 1952, Vol. 42, Nos. 7/8, pp. 161–167.) The system described covers an area of 9 600 km² and has 34 carrier-frequency terminals. Frequencies in the band 45–185 kc/s are used. Design of coupling capacitors and wide-band h.f. band-stop filters is discussed.

621.395.44 : 621.397.242 **2436**

Planning Fundamentals for Carrier-Frequency Cable Links for Communications.—F. Bath & W. v. Werther. (*Fernmeldetech. Z.*, April 1953, Vol. 6, No. 4, pp. 149–157.) The various types of cable are described and the factors governing repeater spacing are indicated. The particular conditions for the transmission of radio and television programmes in Germany are discussed; for the latter case, using the vestigial-sideband system with a carrier frequency of 1·056 Mc/s, available power permits a repeater spacing of 9 km, the signal/noise level being satisfactory over a distance of 1 000 km.

621.396.61/.62 **2437**

Citizen-Radio Class-A Equipment.—R. L. Borchardt. (*Electronics*, May 1953, Vol. 26, No. 5, pp. 166–169.) A description is given of a f.m. transmitter and companion receiver for the 460–470-Mc/s band allocated to the citizens' radio service. In the transmitter, the third harmonic of a crystal, about 19 Mc/s, is multiplied by 24 to obtain the required frequency. A Type-2C39A valve, designed for use in grounded-grid cavity-type circuits and rated at 100-W maximum anode dissipation, is used as power amplifier with the low dissipation of 10 W to ensure long life. Special features of the receiver to achieve frequency stability are described. With high-gain aerials, mounted as high as possible, reliable communication has been realized within a radius of 30 miles, while ranges up to 57 miles have been recorded.

621.396.619 (083.74) **2438**

Standards on Modulation Systems: Definitions of Terms, 1953.—(*Proc. Inst. Radio Engrs*, May 1953, Vol. 41, No. 5, pp. 612–615.) Standard 53 I.R.E. 11S1.

621.396.619.11/.13 **2439**

Modulation Problems.—U. Kirschner. (*Funk u. Ton*, Feb. 1953, Vol. 7, No. 2, pp. 90–95.) Mathematical analysis by Fourier series and by Carson & Fry's method (464 of 1938) of oscillations, modulated in amplitude, phase or frequency.

621.396.619.16 **2440**

Note on Delta Modulation.—(*Elect. Commun.*, March 1953, Vol. 30, No. 1, pp. 71–74.) A simple method of producing delta modulation is based on consideration of the fact that the process is equivalent to pulse-density modulation combined with quantization in time; a practical circuit is illustrated. An accurate method is described for calculating the distortion introduced by the quantization process; the formula obtained embodies the same law as that given by Libois (2330 of 1952).

621.396.619.16 **2441**

Pulse-Group Coding and Decoding by Passive Networks.—R. F. Blake. (*Proc. nat. Electronics Conf., Chicago,* 1952, Vol. 8, pp. 760–765.) Pulse coding and decoding processes which involve timing, gating, summation, and coincidence detection, can be accomplished by passive networks consisting of delay lines, resistors, and crystal matrices. The individual networks to accomplish the various operations, and their combination for coding and decoding, are discussed. The resulting units require no power or active elements other than the source of the pulse or code group. Preliminary tests of experimental coders and decoders showed them to be particularly suitable for many types of coded-pulse system.

621.396.65 **2442**

Israel Intercity V.H.F. Telecommunication Systems.—L. C. Simpson. (*RCA Rev.*, March 1953, Vol. 14, No. 1, pp. 100–124.) Description of two 12-channel radiotelephone systems linking Jerusalem via Tel-Aviv with Haifa and operating in the 250-Mc/s band. F.m. is used, with frequency multiplexing.

621.396.65 : 621.397.26 **2443**

Microwave Relay Link for Television.—(See 2463.)

621.396.71 **2444**

Organization and Technical Arrangements of the Lüchow Radio Station.—H. Heuser. (*Fernmeldetech. Z.*, March 1953, Vol. 6, No. 3, pp. 116–122.) Description of one of the stations used by the West German Post Office for overseas radio telegraph and telephone services.

621.396.97 **2445**

The Future of Broadcasting.—P. Adorian. (*J. Brit. Instn Radio Engrs*, Feb. 1953, Vol. 13, No. 2, pp. 81–87.) It is suggested that the British broadcasting service might eventually comprise at least two sound and two television programmes. Medium- and long-wave transmitters would provide the overseas services, while listeners in Britain would be catered for in the v.h.f. or u.h.f. bands or by wire relay. The advantages of f.m. in the v.h.f. band are discussed.

621.396.1 **2446**

Radio Spectrum Conservation. [Book Review]—Report of the U.S. Joint Technical Advisory Committee. Publishers: McGraw-Hill, New York, 1952, 221 pp., $5.00. (*Arch. elekt. Übertragung*, April 1953, Vol. 7, No. 4, pp. 207–208.) Factors affecting wavelength allocations are examined, and an 'ideal plan' is worked out. Present-day allocations are critically discussed, and practical methods of making the best use of the available frequency band are indicated.

SUBSIDIARY APPARATUS

621-526 **2447**

A Phase-Plane Approach to the Compensation of Saturating Servomechanisms.—A. M. Hopkin. (*Trans. Amer. Inst. elect. Engrs*, 1951, Vol. 70, Part I, pp. 631–639.)

621-526 **2448**

Network Synthesis by Graphical Methods for A.C. Servomechanisms.—G. A. Bjornson. (*Trans. Amer. Inst. elect. Engrs*, 1951, Vol. 70, Part I, pp. 619–625.) Full paper. See 501 of 1952.

621-526 : 621.3.016.352 **2449**

Calculation of the Attenuation in Filtered Oscillators.—G. Cahen & J. Loeb. (*Ann. Télécommun.*, March 1953, Vol. 8, No. 3, pp. 97–101.) A hypothesis previously used is not required in defining the dynamic characteristics of a control system. A particular class of nonlinear servomechanisms is investigated and stability criteria are discussed. See also 972 of April (Cahen & Loeb), 1279 of May and 1624 of June (Cahen).

621-526 : 621.3.078 **2450**

Some Design Criteria for Automatic Controls.—P. T. Nims. (*Trans. Amer. Inst. elect. Engrs*, 1951, Vol. 70, Part I, pp. 606–611.) The design of control systems to give optimum response is discussed in terms of the area between the graphical representation of a step disturbance and the control response curve. This area, and a 'weighted control area', can be calculated directly from the system parameters and enable the necessary control sensitivities to be determined for optimum response.

621-526 : 621.313.2-8 **2451**

Rotary Amplifiers in Servomechanisms.—G. Lehmann. (*Elect. Commun.*, March 1953, Vol. 30, No. 1, pp. 12–25.) The rotary amplifier consists of a d.c. generator driven at constant speed. The properties of this machine as an amplifier are discussed. Use of this amplifier as power stage for a valve amplifier in servomechanisms is described.

621-526 : 621.392.5 **2452**

Effects of Carrier Shifts on Derivative Networks for A.C. Servomechanisms.—G. M. Attura. (*Trans. Amer. Inst. elect. Engrs*, 1951, Vol. 70, Part I, pp. 612–618.)

621-526 : 621.396.645.37 **2453**

A Note on the Design of Conditionally Stable Feedback Systems.—P. Travers. (*Trans. Amer. Inst. elect. Engrs*, 1951, Vol. 70, Part I, pp. 626–630.) Formulae are presented which relate parameters of the loop transfer function of a conditionally stable system to the relative stability of the system transfer function. The condition is determined for which the system bandwidth is a minimum when the loop transfer function is required to have a specified value at a particular frequency.

621.311.6 **2454**

Power Supplies for Transmitters.—K. Brehm. (*A.E.G. Mitt.*, Sept./Oct. 1951, Vol. 41, Nos. 9/10, pp. 268–274.) Present-day equipment used for supplying power to small or large installations is described.

621.314.263 **2455**

Differential Analyzer Study of Harmonic Power Generation with Nonlinear Impedance Element.—P. E. Russell & H. A. Peterson. (*Trans. Amer. Inst. elect. Engrs*, 1951, Vol. 70, Part I, pp. 917–920.) Full paper. See 812 of 1952.

621.314.57 **2456**

A Gas-Tube Inverter with the Supply Voltage below the Breakdown Voltage.—J. M. Cage & J. C. Schuder. (*Trans. Amer. Inst. elect. Engrs*, 1951, Vol. 70, Part I, pp. 908–912.) Investigation of the operating characteristics of simple circuits using gas-discharge tubes working with direct voltages down to about 5 V.

621.314.634 **2457**

Development of 40-Volt Selenium-Rectifier Plates.—J. T. Cataldo. (*Elect. Mfg*, May 1952, Vol. 49, No. 5, pp. 108–112 . . 330.) Forward and reverse characteristics are given for recently developed 40-V Se rectifiers in a bridge circuit. Results of a 3 500-hr life test showed a voltage drop of about 2%. The use of such plates effects a great reduction in weight compared with post-war 26-V plates.

621.316.722 **2458**

Voltage Stabilization—F. A. Benson. (*Electronic Engng*, April & May 1953, Vol. 25, Nos. 302 & 303, pp.

160–165 & 202–207.) Review paper with 146 references. Results of the latest work on glow-discharge tubes are reported.

621.319.331 **2459**

A New Electrostatic Influence Machine.—P. Jolivet. (*Rev. gén. Élect.*, Jan. 1953, Vol. 62, No. 1, pp. 25–39.) Description of the principles of operation, the construction and performance of a rotary machine operating at atmospheric pressure and giving voltages up to 100 kV.

TELEVISION AND PHOTOTELEGRAPHY

621.397 **2460**

High-Speed Facsimile Equipment.—(*Electronica*, 11th April 1953, Vol. 6, No. 120, pp. 61, 63.) Brief description of Philips equipment with a scanning speed of 40 m/s, the width of the scanning line being ⅓ mm. Reproduction at the receiver is on photographic film.

621.397.24/.26 **2461**

International Television: Radio and Cable 2 000-Mile Network for the Coronation Transmissions.—(*Wireless World*, June 1953, Vol. 59, No. 6, pp. 274–275.) Sketch maps are given which show (*a*) the complete system of British television stations, (*b*) the radio-link system permitting re-radiation of the B.B.C. transmissions by stations in France, Holland and Western Germany.

621.397.242 : 621.395.44 **2462**

Planning Fundamentals for Carrier-Frequency Cable Links for Communications.—Bath & v. Werther. (See 2436.)

621.397.26 : 621.396.65 **2463**

Microwave Relay Link for Television.—(*Elect. Commun.*, March 1953, Vol. 30, No. 1, pp. 3–8.) This radio link in its present form operates in one direction only, to transmit television programmes from Louisville, Kentucky, on the U.S. national network, to Nashville, Tennessee. Five repeater stations are incorporated, alternate stages using frequencies from the 2·008–2·025-kMc/s and 2·042–2·059-kMc/s channels respectively. The repeater aerial systems comprise vertically radiating paraboloids about 9 ft above ground, associated with plane wire-mesh reflectors at the top of a tower.

621.397.335 : 535.623/.624 **2464**

Synchronization in Color Television.—D. G. Fink. (*Electronics*, May 1953, Vol. 26, No. 5, pp. 170–175.) Phase synchronization is a necessary and sufficient condition for proper operation of a television system, since the existence of a stationary phase relation implies frequency synchronism. Four types of phase synchronization which must be accomplished in a satisfactory colour-television system are discussed. A table of the phase-synchronism requirements shows that the most difficult synchronization problem in colour television is not that of colour phase, but that of maintaining vertical scanning sufficiently precise to secure proper interlacing.

621.397.5 : 535.623].001.42 **2465**

Recommendations of the National Television System Committee for a Color Television Signal.—A. V. Loughren. (*J. Soc. Mot. Pict. Telev. Engrs*, April 1953, Vol. 60, No. 4, Part I, pp. 321–336.) The original N.T.S.C. specification [1750 of 1952 (Hirsch et al.)] is discussed, and the method of deriving the signal is described. Details are given of the signal specification as revised in February 1953, incorporating modifications made in the light of the preliminary field tests. See also 1822 of June (Fisher) and 2466 below.

621.397.5 : 535.623].001.42 **2466**

Revised Specifications for Field Test of N.T.S.C. Compatible Color Television.—W. R. G. Baker. (*Proc. Inst. Radio Engrs*, May 1953, Vol. 41, No. 5, pp. 666–667.) Full test of the specifications approved by the N.T.S.C. in February, 1953.

621.397.5 : 535.623 : 621.397.822 **2467**

Effects of Noise on N.T.S.C. Color Standards.—C. H. Jones. (*Proc. nat. Electronics Conf., Chicago*, 1952, Vol. 8, pp. 185–200.) To analyse the effect of noise on a colour-television system, the concept of a colour solid is used. One dimension is determined by the amplitude of the black-and-white modulation envelope. The other two dimensions in polar form consist of the magnitude and phase angle of the 3·9-Mc/s colour-subcarrier signal. The Munsell colour solid specifies in an ideal way the visual relation existing among colours. To compare the N.T.S.C. solid with the ideal, contours of Munsell value (related to luminosity), hue, and chroma (saturation) have been plotted. An examination of these contours shows what colours are most influenced by noise. The present N.T.S.C. system is found to be fairly good as regards the effect of noise on brightness and chromaticity. The signal/noise ratio for brightness would be slightly improved by using a gamma a little lower than 2·75. The chromaticity signal/noise ratio can be appreciably improved by adjustment of the amplitudes and phases of the three colour components and by applying the gamma to the *Y* coefficient of the chromaticity portion of the signal.

621.397.5 : 778.5 **2468**

Television Recording.—W. D. Kemp. (*J. Soc. Mot. Pict. Telev. Engrs*, April 1953, Vol. 60, No. 4, Part I, pp. 367–384.) Shortened version of paper noted in 847 of March.

621.397.6 **2469**

Television Standards Converter.—(*Wireless World*, June 1953, Vol. 59, No. 6, p. 273.) A general description is given of the principles of operation of equipment used for converting the British 405-line coronation-broadcast signals to the continental 625-line standard at Breda, Holland. The operating principle is basically the same as that of the equipment used by the B.B.C. in 1952 for changing from French to British standards. The incoming picure is displayed on the 5-in. screen of a c.r. tube used as a flying-spot scanner. The scanning beam of the 625-line camera is arranged to 'read' the picture at an approximately constant time interval behind the 'writing' spot of the c.r. tube. The two scanning systems are locked together by synchronization methods, and spot wobbling is used to fill in the gaps in the 405-line picture, thus avoiding interference patterns appearing in the 625-line picture.

621.397.6.001.4 **2470**

Television Test Equipment.—Mittelmann. (See 2396.)

621.397.62 **2471**

Adaptation of French Television Receivers for American TV Standards.—P. Roques. (*TSF et TV*, March 1953, Vol. 29, No. 293, pp. 84–87.) Outline of alterations necessary for converting an 819-line receiver to 525-line operation.

621.397.62 : 535.88 **2472**

Special Problems in Television Large-Picture Installations.—E. Schwartz. (*Funk u. Ton*, Feb. 1953, Vol. 7, No. 2, pp. 53–73.) See 1168 of April.

621.397.62 : 535.88 **2473**

The Fischer Large-Screen Projection System.—E.

Baumann. (*J. Soc. Mot. Pict. Telev. Engrs*, April 1953, Vol. 60, No. 4, Part I, pp. 344–356.) Reprint. See 2350 of 1952.

621.397.62 : 535.88 : 535.623 **2474**

Eidophor System of Theater Television.—E. I. Sponable. (*J. Soc. Mot. Pict. Telev. Engrs*, April 1953, Vol. 60, No. 4, Part I, pp. 337–343.) Brief description of equipment installed in a New York theatre, comprising eidophor equipment modified to give colour pictures.

621.397.62 : 621.385.2 : 546.289 **2475**

The Germanium Diode as Video Detector.—W. B. Whalley, C. Masucci & N. P. Salz. (*Proc. Inst. Radio Engrs*, May 1953, Vol. 41, No. 5, pp. 638–644.) The Ge diode is particularly suitable for use as a video detector on account of its high forward conductance, low intrinsic capacitance and high back resistance, giving good wide-band operation. Methods of measuring the various characteristics are described and analysis of the operation of the crystal diode as a video detector is presented, the forward and back conductances being assumed constant over the operation range, loads with large and with small time constants being considered.

621.397.62 : 621.397.828 **2476**

Reducing Radiation from TV Receivers.—P. S. Rand. (*Electronics*, May 1953, Vol. 26, No. 5, pp. 130–135.) Quantitative measurements of the radiation from a screened oscillator, simulating the local oscillator of a television receiver, show that complete suppression of radiation can be achieved if suitable methods of screening and filtering are used, particularly for power leads.

621.397.62.001.4 **2477**

Measurements on Television Receivers: Part 1—General Survey.—O. Macek. (*Arch. tech. Messen*, Feb. 1953, No. 205, pp. 41–42.) Receiver circuits and the 625-line and 525-line standards are reviewed as a preliminary to the discussion of appropriate receiver tests.

621.397.621.2 : 621.316.722.2 **2478**

Practical Considerations in Line Time Base Output Stages with Booster Circuit.—C. J. Boers & A. G. W. Uitjens. (*Electronic Applic. Bull.*, Aug. 1951, Vol. 12, No. 8, pp. 137–151.) Simple relations are derived by means of which the numbers and ratio of turns, the voltages and the currents of the line-timebase output transformer can be calculated approximately. Various methods of feeding the heater of the booster diode are indicated. Practical examples are calculated.

621.397.621.2 : 621.316.729 **2479**

Flywheel Synchronization of Timebase Generators: Part 1 — Flywheel Action of Resonant Circuits.—P. A. Neeteson. (*Electronic Applic. Bull.*, Sept. 1951, Vol. 12, No. 9, pp. 154–171.) Detailed analysis of the response of a parallel resonant circuit to a series of periodic pulses of short duration.

621.397.621.2 : 621.316.729 **2480**

Flywheel Synchronization of Timebase Generators: Part 2 — Automatic Phase Control.—P. A. Neeteson. (*Electronic Applic. Bull.*, Oct./Nov. 1951, Vol. 12, Nos. 10/11, pp. 179–199.) Discussion of circuits in which synchronization is obtained by deriving a control voltage from the phase shift between the synchronizing signal and the relaxation voltage, the control voltage being then applied to the control grid of the valve in which the relaxation voltage is generated. Several practical circuits for a.ph.c. are described and their operation is discussed. Part 1: 2479 above.

TRANSMISSION

621.396.61 : 621.396.619.11 **2481**

Output Analysis and Alignment Techniques for Phase-Rotation Single-Sideband Transmitters.—O. Whitby & D. R. Scheuch. (*Trans. Amer. Inst. elect. Engrs*, 1951, Vol. 70, Part I, pp. 209–212.) Discussion with reference to the type of transmitter described by Villard (893 of 1949). The two balanced modulators are driven by r.f. voltages in quadrature. A.f. modulating voltages, also in quadrature, are applied in push-pull to the valve grids of each modulator. The anode-current pulses of all the four Eimac Type 4-250A valves used develop power in a common anode tank circuit. When properly operated, only one sideband is present in the output. Details of the alignment procedure are given, and a specially developed alignment indicator is described which consists essentially of a single-frequency test source of four quadrature a.f. modulating voltages and four gated phase-sensitive detectors, each one of which is assigned to the examination of one particular component in the detected output of the transmitter.

621.396.61.018.3 **2482**

The Output-Stage Harmonic Power radiated from the Transmitter Aerial.—K. Freudenhammer. (*Fernmeldetech. Z.*, April 1953, Vol. 6, No. 4, pp. 158–164.) For a given harmonic the power radiated is maximum when the aerial circuit resonates at this frequency as well as at the fundamental. A simple formula is derived for this case, in which the power is expressed in terms of the damping of the individual circuits between output valve and aerial, the ratio of harmonic to fundamental valve current and the ratio of harmonic to fundamental radiation resistance. Various types of coupling and aerial are compared from the point of view of obtaining the lowest possible radiation of harmonics.

621.396.615.141.2 : 621.396.619.11 **2483**

Measurements on an Amplitude-Modulated Injection-Locked U.H.F. Magnetron Transmitter.—L. L. Koros. (*Proc. nat. Electronics Conf., Chicago*, 1952, Vol. 8, pp. 395–406.) See 1060 of April.

621.396.619.11/.13 **2484**

The Spectral Differences between Amplitude- and Frequency-Modulated Oscillations.—A. Raschkowitsch. (*Frequenz*, Feb. 1953, Vol. 7, No. 2, pp. 37–41.) Comparison is made between the frequency spectrum of the sidebands of f.m. oscillations with small frequency swing and that of a.m. oscillations with a square-law modulator characteristic. Discussion of the results of this comparison shows the necessity of using a large frequency swing, and that f.m. is particularly suitable for the u.s.w. band.

621.396.619.23 : 621.385.2 **2485**

Diode Modulators for Frequency Modulation.—A. Raschkowitsch. (*Frequenz*, Feb. 1953, Vol. 7, No. 2, pp. 49–53.) The internal resistance of a diode decreases with increasing anode voltage, passes through a minimum value at about 7 V and then rises to a very high value at saturation. This property is utilized in a simple modulator in which the anode of a class-A control triode is connected direct to the cathode of the diode, with a capacitive connection to earth. Using only the straight portion of the triode characteristic, the diode internal resistance varies linearly with the modulation voltage applied to the grid of the triode, thus causing variation of diode current and f.m. of an oscillator capacitively coupled to the diode anode. Theory of the method is based on equivalent circuits. In a practical example, a frequency swing of ± 15 kc/s was obtained on an oscillator frequency of 10 Mc/s.

VALVES AND THERMIONICS

537.525.92 : 537.533.7 **2486**

Space-Charge Waves in Electron Streams.—J. Labus. (*Elektrotech. Z., Edn A*, 1st March 1953, Vol. 74, No. 5, pp. 129–130.) Two methods of calculating the phase constants of space-charge waves are discussed.

621.314.7 **2487**

Factors in the Design of Point-Contact Transistors.—B. N. Slade. (*RCA Rev.*, March 1953, Vol. 14, No. 1, pp. 17–27.) The characteristics of point-contact transistors depend essentially on four factors, namely (*a*) the materials used for the point contacts, (*b*) the spacing of the point contacts, (*c*) the resistivity of the Ge, and (*d*) the electrical forming process. The design of transistors for use in r.f. amplifiers, oscillators and switching or counter circuits is discussed with reference to these factors. See also 585 of February (Rose & Slade) and 884 of March.

621.314.7 **2488**

Interpretation of α-Values in *p-n* Junction Transistors.—F. S. Goucher & M. B. Prince. (*Phys. Rev.*, 1st Feb. 1953, Vol. 89, No. 3, pp. 651–653.) Measurements of the current amplification factor were made for five *n-p-n* junction transistors and one *p-n-p* junction transistor. For all six samples, the results obtained by three different methods agreed within the limits of experimental error.

621.314.7 **2489**

Junction-Transistor Characteristics at Low and Medium Frequencies.—L. J. Giacoletto. (*Proc. nat. Electronics Conf., Chicago*, 1952, Vol. 8, pp. 321–329; *Tele-Tech*, March 1953, Vol. 12, No. 3, pp. 70–72 . . 125.) The characteristics of junction-type transistors are reviewed and methods of measuring their parameters are described. The results of such measurements have pointed the way to constructional modifications permitting operation at frequencies > 10 Mc/s. See also 644 of March.

621.314.7 **2490**

Properties of Junction Transistors.—K. D. Smith. (*Proc. nat. Electronics Conf., Chicago*, 1952, Vol. 8, pp. 330–342.) Factors of importance in the design and application of *n-p-n*-junction transistors are discussed in detail and the relations of some of the design variables to the parameters of the equivalent circuit are considered. The results of measurements of various characteristics for the development type M1752 are shown graphically and new models designed for power dissipation of the order of 3 W are noted; a power gain of 26 db is obtained.

621.314.7 **2491**

Some Transient Properties of Transistors.—H. G. Bassett & J. R. Tillman. (*Brit. J. appl. Phys.*, April 1953, Vol. 4, No. 4, pp. 116–117.) Tests carried out on point-contact transistors of British manufacture show that the growth and decay of the collector current, in response to a rectangular pulse of emitter current, are roughly exponential after an initial delay of the order of 0·1 μs, during which there is no response. If the collector current is saturated, or if the collector voltage, instead of being steadily applied, is pulsed on, during or after application of the pulse of emitter current, effects due to delayed carriers are strikingly exhibited.

621.383.27 **2492**

The Dark Current in Photomultipliers.—N. Schaetti & W. Baumgartner. (*Z. angew. Math. Phys.*, 15th March 1953, Vol. 4, No. 2, pp. 159–160. In German.) Continuation of work noted in 1518 of May. Further measurements on Cs-Sb photocathodes provide evidence of photoconduction and crystal-phosphor effects as well as photoemission.

621.385 **2493**

Change of Electron Temperature in an Electron Beam.—H. M. Mott-Smith. (*J. appl. Phys.*, March 1953, Vol. 24, No. 3, pp. 249–255.) The change in velocity distribution within a beam on issuing from an accelerating grid into a field-free space is calculated by direct integration of the Boltzmann equation. For electron densities and velocities typical of travelling-wave valves and diodes, the effect of electron collisions is negligible, as is also the longitudinal component of the electron-gas pressure; the usual heat-conduction formulae of kinetic theory do not hold.

621.385 : 669.245 **2494**

The Use of Nickel in Valves.—Jackson & Jenkins. (See 2357.)

621.385-71 **2495**

Basic Heat-Transfer Data in Electron Tube Operation.—B. O. Buckland. (*Trans. Amer. Inst. elect. Engrs*, 1951, Vol. 70, Part 1, pp. 1079–1085.) Full paper. See 1774 of 1952.

621.385.029.6 **2496**

Low-Noise Traveling-Wave Tube.—A. G. Peifer, P. Parzen & J. H. Bryant. (*Elect. Commun.*, March 1953, Vol. 30, No. 1, p. 60.) Correction to paper noted in 273 of January.

621.385.029.6 **2497**

Theory of the Large-Signal Behavior of Traveling-Wave Amplifiers.—A. Nordsieck. (*Proc. Inst. Radio Engrs*, May 1953, Vol. 41, No. 5, pp. 630–637.) Calculations are made of the amplification, output phase distortion and harmonic content for a travelling-wave valve operated beyond its linear range. Space-charge effects are neglected. The limiting efficiency and phase distortion are given for various values of the beam-to-circuit coupling factor and of the electron injection velocity. The relative harmonic content in the output is given for all harmonics up to the fifth. Nearly all the results are presented graphically.

621.385.029.63/.64 **2498**

Waves in an Electron Stream with General Admittance Walls.—C. K. Birdsall & J. R. Whinnery. (*J. appl. Phys.*, March 1953, Vol. 24, No. 3, pp. 314–323.) The influence of wall admittance on the operation of electron-stream valves is investigated, using the method of field analysis. Values of gain and phase velocity are calculated for walls of arbitrary admittance. Design is facilitated by use of charts showing contours of the complex functions involved. Gain is zero for open or short circuit and for capacitive wall impedance, low for resistive-capacitive, higher for resistive and resistive-inductive, and highest for inductive walls. Results for the case of the resistive-capacitive wall were verified by experiments using a very thin glass tube coated on the inside with a layer of tin oxide. No immediate practical application is envisaged for the particular structures discussed.

621.385.029.63 **2499**

Measurements on a 10-W Helix-Type Travelling-Wave Valve for 15-cm Wavelength.—H. Schnitger & D. Weber. (*Fernmeldetech. Z.*, Feb. 1953, Vol. 6, No. 2, pp. 66–72.) The design and performance of a travelling-wave valve designed to give a power gain of 17 db at 2 kMc/s are described. Details are given of the helix construction, the capacitive coupling arrangement which simplifies valve changing, and the beam focusing system. The observed efficiency of about 20% is in fair agreement with theoretical calculations. Measurements have been made to determine the optimum distance between helix input and a graphite coating on the outside of the glass envelope for suppression of self oscillations.

621.385.029.63 : 621.396.619.23 **2500**

The Electron Coupler — a Developmental Tube for Amplitude Modulation and Power Control at Ultra-High Frequencies.—C. L. Cuccia. (*RCA Rev.*, March 1953, Vol. 14, No. 1, pp. 72–99.) For another account see 2188 of July.

621.385.032.212 **2501**

Cold-Cathode Valves.—H. L. von Gugelberg. (*Bull. schweiz. elektrotech. Ver.*, 7th Feb. 1953, Vol. 44, No. 3, pp. 81–87. In German.) Recent developments in voltage-stabilizer, relay, photo-flash and decade-counter tubes are reviewed.

621.385.032.216 **2502**

New Dispenser-Type Thermionic Cathode.—R. Levi. (*J. appl. Phys.*, Feb. 1953, Vol. 24, No. 2, p. 233.) Brief preliminary note about the 'impregnated' cathode, a development of the 'L' cathode previously described by Lemmens et al. (773 of 1951). Instead of using Ba and Sr carbonates contained in a cavity, the new cathode uses Ba aluminates dispersed within the pores of the W plug.

621.385.032.216 **2503**

The Effects of Oxygen on the Electrical Properties of Oxide Cathodes.—A. A. Shepherd. (*Brit. J. appl. Phys.*, March 1953, Vol. 4, No. 3, pp. 70–75.) Experiments on (Ba, Sr)O cathodes were made using mass-spectrometer and probe methods to examine the effects of oxygen poisoning on emission and conductivity. Results show that increased oxygen ion emission occurs during recovery and that most of this originates within the body of the coating. This supports the work of Metson (3588 of 1949). The conclusion is drawn that poisoning is mainly due to an increase in work function, this being caused by adsorption of oxygen on the inter or crystal surfaces as well as on the outer coating. Results at all temperatures for emission and at high temperatures for conductivity support this. Conductivity results in general can be accounted for by the Loosjes-Vink conduction mechanism (491 of 1950) although this does not explain the discrepancy between cathode work function and high-temperature activation energy.

621.385.032.216 : 537.311.33 **2504**

The Interpretation of Nijboer Theory for BaO from the Viewpoint of Co-existence of Various Impurity Levels.—S. Narita. (*J. phys. Soc. Japan*, March/April 1952, Vol. 7, No. 2, pp. 221–222.)

621.385.032.216 : 621.397.62 **2505**

Cathode-Interface Effects in TV Receiver Design.—F. M. Dukat & I. E. Levy. (*Electronics*, April 1953, Vol. 26, No. 4, pp. 169–171.) Undesirable effects, notably reduction of gain and deterioration of low-frequency response, due to the development of cathode-interface impedance are discussed. This resistance increases with decrease of cathode temperature and with decrease of cathode area. Relevant characteristics of some commercial valve types are tabulated and compared. The discussion applies also to car radio receivers, where trouble may occur when valves are operated at low heater voltages.

621.385.032.216.1 : 546.841.4-31 **2506**

Thermionic Properties of Thoria.—G. Mesnard. (*Le Vide*, Nov. 1952, Vol. 7, No. 42, pp. 1256–1261.) From results of measurements on the emission of thoria-coated tungsten filaments, the optimum working temperature is found to be between 1 900° and 2 000°K. The values of the constants A and ϕ in Richardson's equation corresponding to different activation treatments are determined. See also 2730 of 1951.

621.385.032.216.1 : 546.841.4-31 **2507**

Changes with Time in Thoria-Coated Thermionic Cathodes.—G. Mesnard. (*Le Vide*, Jan. 1953, Vol. 8, No. 43, pp. 1273–1279.) An investigation of emission variations which occur at fixed operating temperatures following activation treatment. Purely thermal effects and effects of current are distinguished. Temperature variations due to current in a tungsten filament with its central portion coated with thoria are tabulated. See also 2506 above.

621.385.032.216.1 : 546.841.4-31 **2508**

Thoria Cathodes.—G. Mesnard. (*C. R. Acad. Sci., Paris*, 2nd March 1953, Vol. 236, No. 9, pp. 904–906.) Further experiments on thoria cathodes are described which show the existence of a considerable temperature gradient in the thoria coating. This gradient becomes much less after treatment at 1 900–2 000°K, owing to crystallization of the thoria. New measurements of the conductivity were made by using a very fine electrode in contact with the thoria surface, the second electrode being the W-wire support. The results are discussed in relation to previous investigations (504, 774 and 2730 of 1951). Thoria appears to be a semiconductor of the *n* type.

621.385.2 : 537.525.92 **2509**

Space-Charge-Limited Currents between Inclined Plane Electrodes. Approximate Solutions.—H. F. Ivey. (*J. appl. Phys.*, Feb. 1953, Vol. 24, No. 2, p. 227.) Simplified formulae are derived for the 'perveance function' and 'trajectory magnification factor' introduced in a previous paper (2384 of 1952).

621.385.2 : 546.289 : 621.397.62 **2510**

The Germanium Diode as Video Detector.—Whalley, Masucci & Salz. (See 2475.)

621.385.2 : 621.3.016.35 **2511**

Measurements of Saturated-Diode Stability.—V. H. Attree. (*Brit. J. appl. Phys.*, April 1953, Vol. 4, No. 4, pp. 114–116.) Results are given of tests on Mazda Type-29C1 diodes run for 1 000 hr at emission currents of 5 mA and 0·5 mA. The filament current, for a given emission, shows smaller variations than the voltage, and results at 0·5 mA are much better than at 5 mA emission. At 0·5 mA the filament current is constant to within 1 part in 500 over the 1 000-hr period. Tests on a single Ferranti Type-GRD6 diode also show that for constant emission the filament current variations are very much less than those of the filament voltage.

621.385.2 : [621.317.3 + 621.316.72 **2512**

Saturated-Diode Operation.—H. L. Armstrong: V. H. Attree. (*Electronic Engng*, May 1953, Vol. 25, No. 303, p. 216.) Comment on 1197 of April and author's reply.

621.385.2.032.213.1 **2513**

Approximate Formulae for the Saturation Current of Diodes with Tungsten Cathodes.—E. Dzhakov. (*Zh. tekh. Fiz.*, April 1952, Vol. 22, No. 4, pp. 602–605.)

621.385.3 **2514**

Design Rules for Planar Triodes.—W. Dahlke. (*Telefunken Ztg*, Jan. 1953, Vol. 26, No. 98, pp. 54–60.) Charts are provided to facilitate the determination of the various dimensions of a planar triode for a specified slope of the characteristic and a specified operating current. Numerical calculations for the Telefunken pentode, Type EF80, are in good agreement with measured values.

621.385.832 : 621.318.57 **2515**

A Decimal Counter Electron Tube.—D. L. Hollway. (*Aust. J. Phys.*, March 1953, Vol. 6, No. 1, pp. 96–115.) A detailed description is given of the construction and operation of the counter tube noted in 2374 of 1950. A 4-tube counter is described capable of counting speeds from 70 000 to 180 000/sec, depending on circuit conditions.

621.387 : 621.316.722 : 621.396.822 **2516**

Peak-Noise Characteristics of some Glow-Discharge Tubes.—H. Bache & F. A. Benson. (*J. sci. Instrum.*, April 1953, Vol. 30, No. 4, pp. 124–126.) Results of further measurements on voltage-regulator tubes, including miniature and also relatively-large-current tubes, are shown graphically. See also 2930 and 2931 of 1952.

621.387.004.15 **2517**

Improving Gas-Tube Grid-Circuit Reliability.—J. H. Burnett. (*Proc. nat. Electronics Conf., Chicago*, 1952, Vol. 8, pp. 568–576; *Tele-Tech*, April 1953, Vol. 2, No. 4, pp. 70–72 . . 175; *Elect. Engng, N.Y.*, April 1953, Vol. 72, No. 4, pp. 341–346.) Several sources of noise in the grid circuits of thyratrons are discussed and practical methods of noise reduction to obtain improved performance are outlined.

621.396.615.141.2 **2518**

The Turbator, a Single-Cavity Magnetron.—F. Lüdi. (*Tijdschr. ned. Radiogenoot.*, March 1953, Vol. 18, No. 2, pp. 89–103. In German.) See 2945 of 1950.

621.396.615.141.2 **2519**

Grid Magnetron delivers Modulated U.H.F. Output.—P. L. Spencer. (*Electronics*, May 1953, Vol. 26, No. 5, pp. 148–153.) A highly stable magnetron is described which has a set of grid wires located in the gaps between the tips of the anode vanes. Details are given of a valve of this type which has a tuning range of ± 50 Mc/s centred near 2·35 kMc/s, and a c.w. power output of 50 W. Frequency stability, achieved through grid injection of signals from a crystal-controlled oscillator, should prove particularly advantageous in u.h.f. television broadcasting, Doppler radar, and in subcarrier multiple-relay services. The grid provides an excellent means of injecting video modulation signals. Circuit diagrams, with component details, are given for a suitable video amplifier and modulator, and also for a generator, video amplifier and modulator for a subcarrier system, a cathode follower being used for grid drive of the magnetron.

MISCELLANEOUS

025.45 **2520**

Meaning and Purpose of the Decimal Classification.—O. C. Hilgenberg. (*Elektrotech. Z., Edn A*, 1st April 1953, Vol. 74, No. 7, pp. 205–207.) The general principles on which the U.D.C. system is based are clearly explained and are illustrated by numerous examples.

061.3 : [55 + 621.396.11 **2521**

International Scientific Radio Union: Meeting in Sydney.—R. L. Smith-Rose. (*Nature, Lond.*, 11th April 1953, Vol. 171, No. 4354, pp. 628–631.) A general account of the tenth general assembly of U.R.S.I., held during 11th–21st August 1952, with summaries of the proceedings of the various Commissions.

061.3 : [55 + 621.396.11 **2522**

Tenth General Assembly of U.R.S.I.—(*Onde élect.*, March 1953, Vol. 33, No. 312, pp. 127–190.) An account is given of the organization and development of the Union, and reports are presented of the discussions of the individual commissions, dealing respectively with the following subjects:—measurements, the troposphere and wave propagation, the ionosphere and wave propagation, atmospherics, radio astronomy, information theory, electronics.

061.4 : [621.317.7 + 621.38 **2523**

Physical Society's Exhibition [1953].—(*Wireless Engr*, May 1953, Vol. 30, No. 5, pp. 124–129.) Brief descriptions are given of a selection of the exhibits. See also *Electronic Engng*, May 1953, Vol. 25, No. 303, pp. 212–215.

061.4 : [621.396.6 + 621.317.7 + 621.38 **2524**

Components and Techniques. Survey of the R.E.C.M.F. and Physical Society's Exhibitions.—(*Wireless World*, June 1953, Vol. 59, No. 6, pp. 246–255.) Short descriptions of selected exhibits, with lists of exhibitors in the sections dealing with components.

621.38/.39(47) **2525**

A Look at Russian Radio and Electronics.—G. B. Devey. (*Proc. nat. Electronics Conf., Chicago*, 1952, Vol. 8, pp. 358–364.) Some information is given on Russian technical literature, and also on the development of an ultrasonic microscope, research on semiconductors, and the use of ultrasonics to accelerate the action of H_2SO_4 in the surface cleaning of steel, with references to the Russian journals in which these developments are described.

621.39 (083.74/.75) **2526**

Standardization and Telecommunications.—R. Goret. (*Ann. Télécommun.*, Jan. 1953, Vol. 8, No. 1, pp. 11–18.) An account is given of the structure and operation of the commission set up in France in 1945 to study the standardization of telecommunications equipment. Specifications established by the commission are listed and discussed.

621.396 **2527**

Radio Progress during 1952.—(*Proc. Inst. Radio Engrs*, April 1953, Vol. 41, No. 4, pp. 452–507.) A review including over 1 000 references to world literature. Material is arranged under the headings indicated in 2404 of 1952, with additional sections on Feedback Control Systems and on Magnetics.

621.396.001.891(41-41) **2528**

Radio Research in the British Commonwealth.—(*Nature, Lond.*, 18th April 1953, Vol. 171, No. 4355, pp. 683–684.) A short review of investigations in many Commonwealth countries of ionospheric conditions and propagation at various frequencies, r.f. noise measurements in the ranges 15–500 kc/s and 2–20 Mc/s, study of meteors by radio methods, radio astronomy, standard-frequency transmissions, effects of terrain on radio propagation, forecasting of ionospheric storms and of radio propagation conditions, and comparison of forecasts with observations.

621.396.6 **2529**

New Components.—(*Rad. tech. Dig., Édn franç.*, 1953, Vol. 7, No. 1, pp. 29–37.) A brief survey of new radio and allied equipment on the French market.

621.396 **2530**

The Radio Amateur's Handbook. [Book Review]—Publishers: American Radio Relay League, West Hartford, Conn., 30th edn, 1953, 800 pp., $3.00. (*Electronics*, May 1953, Vol. 26, No. 5, pp. 403–404.)

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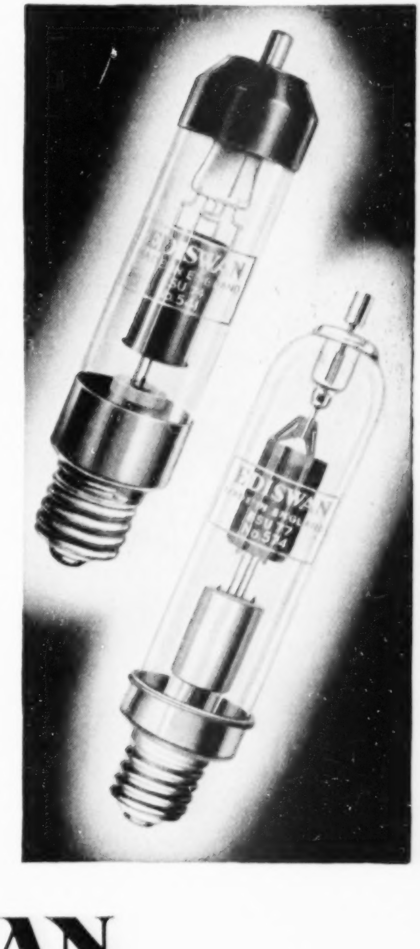

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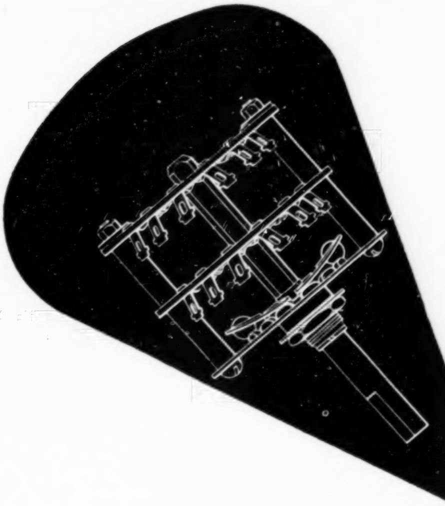

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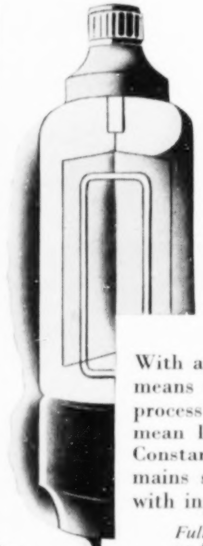

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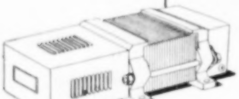

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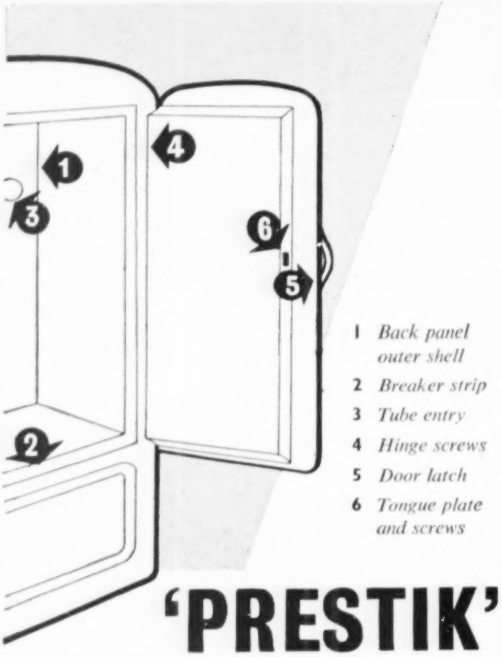

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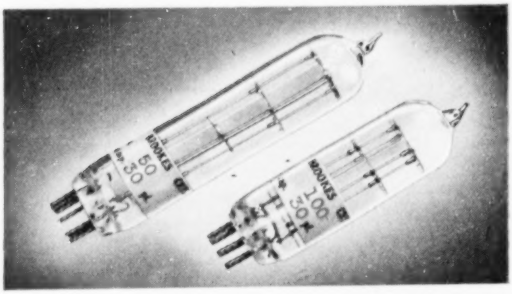

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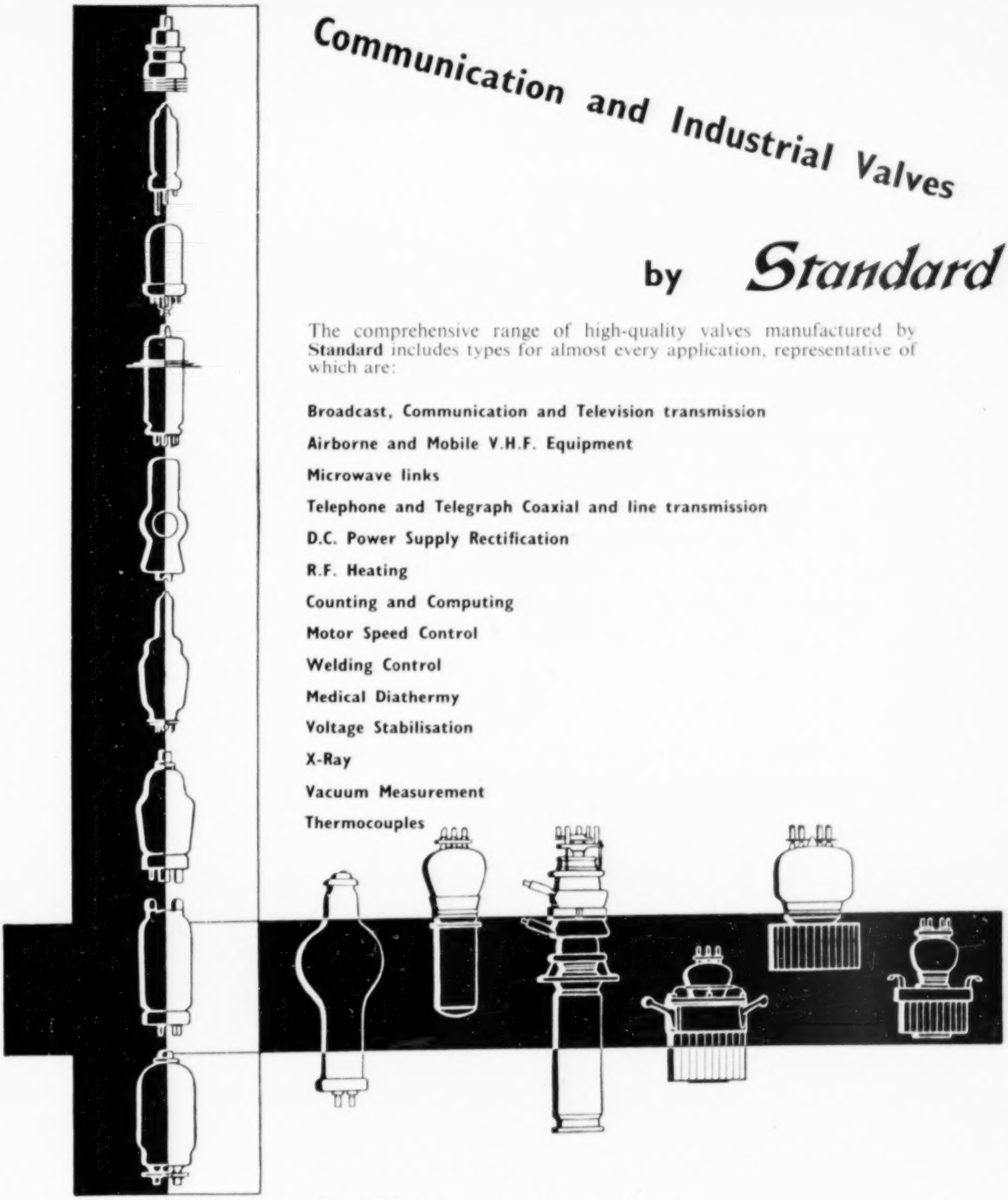

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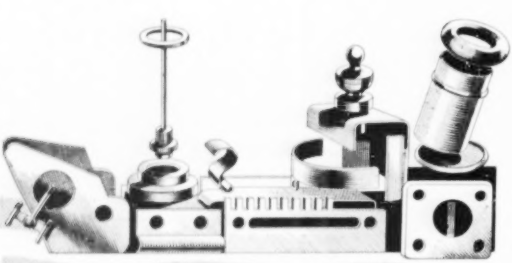

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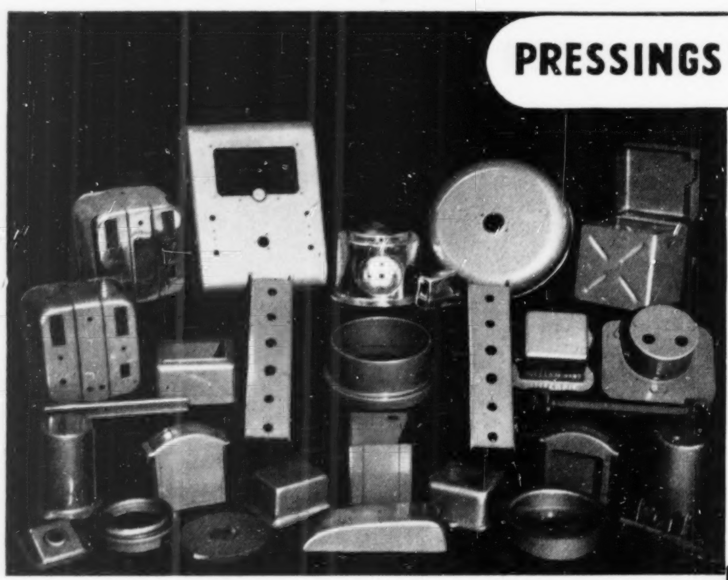

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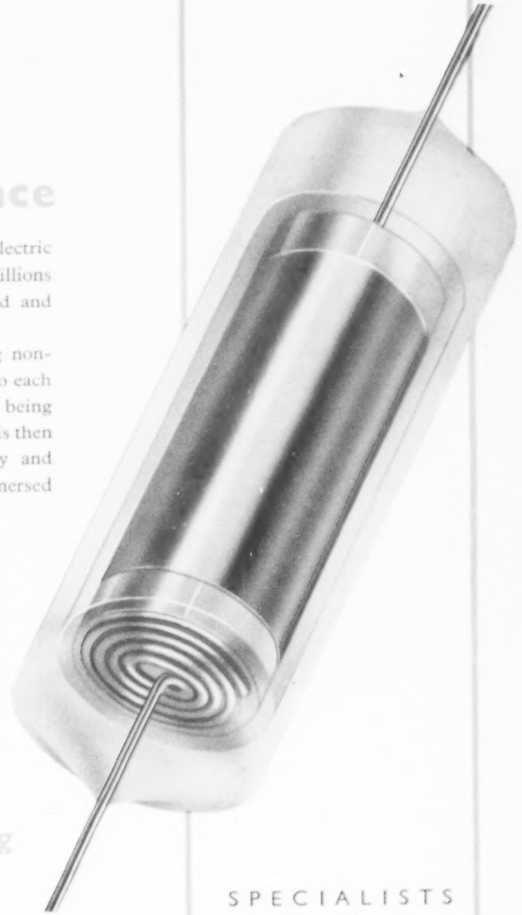

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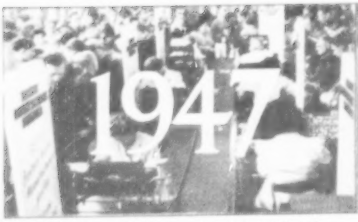

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